

Lower Esophageal Mucosal Ring: Correlation of Referred Symptoms with Radiographic Findings Using a Marshmallow Bolus

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OBJECTIVE. The purpose of this investigation was to determine the prevalence of lower esophageal mucosal rings and to correlate the relationship between these mucosal rings and the presence and anatomic level of symptoms evoked using a marshmallow bolus.

SUBJECTS AND METHODS. Our prospective study included 130 patients who underwent barium examination of the esophagus. All patients completed a questionnaire regarding the anatomic location of their symptoms of dysphagia. In addition to a multiphasic examination of the esophagus, all patients also underwent fluoroscopic observation and videotaping while swallowing a marshmallow bolus; any symptoms that were provoked were recorded.

RESULTS. Lower esophageal mucosal rings were shown in 26 (20%) of the 130 patients. The diameter of the rings was 9–12 mm in six patients, 13–20 mm in 18 patients, and larger than 20 mm in two patients. In 16 (62%) of the 26 patients, a marshmallow bolus became impacted at the ring; the impaction caused dysphagia in 12 (75%) of the 16 patients. In these 12 patients, dysphagia was referred to the neck in seven, the sternal angle in two, the mid chest in two, and the lower chest in one patient. None of the 12 patients had a pharyngeal or cervical esophageal abnormality that would account for their symptoms.

CONCLUSION. Because proximal referral of symptoms is common in patients with lower esophageal mucosal rings, a thorough radiographic examination of the entire esophagus and esophagogastric region is required regardless of the level of their swallowing complaints.

The lower esophageal mucosal ring is the most common benign narrowing of the esophagus seen radiographically [1]. Mucosal rings are often not symptomatic, but patients may complain of intermittent solid food dysphagia, the prevalence of which relates to the diameter of the ring [2]. A clinical misconception is that symptoms are helpful in localizing the level of an esophageal obstructing lesion. However, referral of dysphagia upward has been reported with achalasia, peptic strictures, reflux esophagitis, and esophagogastric cancers [3–6]. Symptom referral in patients with lower esophageal mucosal rings has not been well documented. We examined a series of patients using radiography supplemented by a marshmallow bolus to assess the prevalence of mucosal rings and to correlate evoked symptoms.

Subjects and Methods

We studied 130 consecutive outpatients referred for barium esophagography or double-con-

trast upper gastrointestinal examination; 68 men and 62 women with a mean age of 50 years (range, 16–90 years) were included; only patients unable to complete the multiphasic examination were excluded. Before radiographic examination, patients completed a questionnaire and were interviewed by a gastrointestinal radiologist or radiology resident. Data were obtained regarding the nature and duration of symptoms and their relationship to the ingestion of food and liquids. Patients complaining of food sticking indicated to the radiologist the anatomic level at which their symptoms occurred. If the patients had any diseases with known association with esophageal dysmotility, this was noted.

A multiphasic radiographic examination of the esophagus and pharynx was performed using remote control equipment [7]. The examinations were done by gastrointestinal radiologists or radiology residents; the latter were supervised during film interpretation and review of the videofluoroscopic findings. Each examination included videofluoroscopy and spot filming of the pharynx in anteroposterior and lateral projections during single swallows of 25 ml of a high-density barium suspension (EZ-HD; E-Z-EM, Westbury, NY); double-contrast views of the thoracic esophagus with the patient upright in the left posterior ob-

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lique position after the patient ingested gas granules and a high-density barium suspension; prone full-column and mucosal relief views of the esophagus; and videofluoroscopy of the esophagus in the prone oblique position during the passage of five single barium swallows [8].

Solid bolus testing was attempted during all examinations by giving the patients half or a third of a standard marshmallow (3 × 3 cm) to swallow, then a small quantity of a diluted barium suspension (Solopaque; E-Z-EM); the patients were asked not to chew the marshmallow [9]. The passage of the marshmallow was observed videofluoroscopically, and if impaction occurred, the site was noted; spot filming was done when impaction was observed. Immediately after the swallow, patients were asked whether their presenting symptoms were reproduced by the solid bolus and, if so, to localize the anatomic level of the evoked symptoms.

TABLE I Prevalence of Marshmallow Bolus Impaction and Reproduction of Dysphagia			
Ring Diameter (mm)	No. of Patients	Impaction (%) ^a	Occurrences of Dysphagia ^b
9–12	6	4 (66)	3/4 (75)
13–20	18	12 (66)	9/12 (75)
>20	2	0 (0)	0 (0)
Total	26	16 (62%)	12/16 (75%)

^aImpaction of marshmallow at level of lower esophageal mucosal ring.

^bProvoked in patients by impaction of marshmallow bolus.



Fig. 1.—75-year-old man with progressive solid food dysphagia. Barium esophagogram shows marshmallow (M) impacted at 12-mm mucosal ring (arrows), which reproduced dysphagia that was referred to neck.



Fig. 2.—52-year-old man with solid food dysphagia. Barium esophagogram shows impaction of marshmallow (M) at 16-mm mucosal ring (arrows), which caused dysphagia referred to sternal notch.

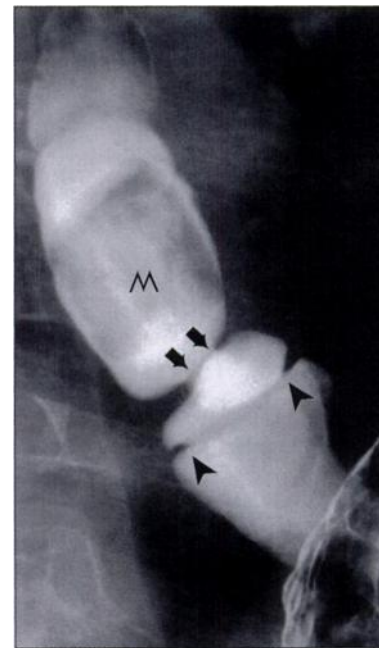


Fig. 3.—78-year-old man with intermittent dysphagia. Barium esophagogram shows marshmallow (M) impacted at muscular ring (arrows); wide lower esophageal mucosal ring (arrowheads) was also present.

The diagnosis of a lower esophageal mucosal ring was made when a smoothly marginated thin transverse structure with a fixed internal diameter was shown at the esophagogastric junction [1, 2, 10, 11]. The maximum caliber of the ring was measured using the radiographs with the lower esophagus distended with barium suspension. The largest diameter of the marshmallow bolus in patients with impaction was also measured; these measurements were not corrected for magnification.

Results

Lower esophageal mucosal rings were found in 26 (20%) of 130 patients; the mean age of patients with rings was 64 years (range, 35–82 years). The main presenting complaints in the 26 patients were food sticking in the throat or chest ($n = 21$), heartburn ($n = 3$), chest pain ($n = 1$), and epigastric pain ($n = 1$). Duration of symptoms ranged from 3 weeks to 10 years; symptoms were progressive in 10 patients, intermittent in nine, and variable in the remaining seven. Solid foods provoked symptoms in 20 patients, three had symptoms with both solids and liquids, and three had no symptoms related to eating or drinking.

The 26 lower esophageal mucosal rings measured 9–32 mm in diameter; 23 (88%) of 26 patients swallowed a marshmallow bolus intact, but three (12%) chewed the marshmallow. The rings were categorized into three sizes relative to diameter, and findings related to impaction of the marshmallow bo-

lus at the ring and the reproduction of dysphagia were correlated (Table 1). In the 12 patients in whom impaction provoked dysphagia, symptoms were referred to the neck in seven (58%) (Fig. 1), the sternal angle in two (17%) (Fig. 2), the mid chest in two (17%), and the lower chest in one (8%). The average size of the marshmallow boluses resulting in impaction was 2.5 cm for half a marshmallow ($n = 16$) and 1.9 cm for a third of a marshmallow ($n = 7$). Of the eight patients who had rings 13 mm or wider that did not cause impaction of the marshmallow, three patients chewed the marshmallow. In one patient, the marshmallow became impacted at a coexisting muscular ring (Fig. 3). In the remaining four patients, the bolus did not become impacted at any ring or provoke symptoms; the mucosal rings in these patients measured 20 mm or more in caliber.

Esophageal motility was normal in 21 (81%) of 26 patients with lower esophageal mucosal rings. The remaining five patients had a nonspecific esophageal motility disorder [12]; in these patients, mucosal rings ranged from 10 to 18 mm, and all had impaction of the marshmallow bolus at their rings. Dysphagia was referred to the throat in three patients and to the sternal angle in one patient; the fifth patient was asymptomatic. Although two (8%) of 26 patients with rings had diabetes, both of the diabetic patients had normal esophageal motility.

Correlation of Radiographic Findings in Lower Esophageal Mucosal Ring

Videofluoroscopy of the pharynx had normal findings in 14 (54%) of 26 patients with rings; in the remaining 12 patients, a spectrum of findings was found, including six instances of pharyngeal stasis, three instances of pharyngeal spillover, three instances of laryngeal penetration, one instance of aspiration, one instance of Zenker's diverticulum, and five instances of cricopharyngeal bars. In two patients with Zenker's diverticula and five patients with cricopharyngeal bars, symptom reproduction related to impaction of the marshmallow at their mucosal rings. The cricopharyngeal bar was defined as a posterior impression of 25% or more of the luminal caliber at the pharyngo-esophageal junction during the pharyngeal phase of swallowing. In the five patients with cricopharyngeal bars, marshmallow impaction did not occur at that level. Cricopharyngeal bars were also present in 12 (12%) of the 104 patients without mucosal rings; all of these patients but one were able to swallow a marshmallow bolus that passed the cricopharyngeal level without impaction or production of symptoms.

In the 104 patients without lower esophageal mucosal rings, the main presenting complaints were food sticking in the throat or chest ($n = 52$), heartburn ($n = 20$), chest pain ($n = 7$), epigastric pain ($n = 8$), and other pharyngeal or laryngeal symptoms ($n = 17$; i.e., cough, choking, globus, and hoarseness). The prevalence of food sticking was 50% (52/104) in patients without rings compared with 81% (21/26) in those with mucosal rings.

Impaction of the marshmallow bolus was also observed in 21 (20%) of 104 patients without lower esophageal mucosal rings; six of these had strictures (five in the lower esophagus, one at the pharyngo-esophageal junction), one had a fundoplication and peptic stricture, one had hiatal hernia repair, five had hiatal hernias, and eight were normal. Of the five patients with esophageal stricture only, in four the marshmallow became impacted at their strictures. In these four, symptoms were referred to the neck or lower chest in two; the third patient had no symptoms. The fourth patient with a lower esophageal stricture that caused impaction had mid-esophageal impaction above the stricture with mid chest symptoms; this patient had normal esophageal motility. The patient with a pharyngo-esophageal stricture had impaction of the marshmallow at the stricture, with symptoms referred to that level.

The patient with fundoplication and peptic stricture had impaction above the stricture, with dysphagia referred to the mid chest; this patient had normal esophageal motility. The patient with hiatal hernia repair had asymptomatic

marshmallow impaction in the mid esophagus and also a nonspecific esophageal motility disorder. All five patients with hiatal hernias had impaction of the marshmallow bolus; four had impaction in the lower esophagus, with dysphagia referred to the neck in three (Fig. 4) and one who was asymptomatic. Two of the patients who were symptomatic in the neck had normal motility, and the remaining two patients with impaction in the lower esophagus had nonspecific esophageal motility disorder. One patient with a nonspecific esophageal motility disorder had impaction at the thoracic inlet and dysphagia referred to the sternal notch.

Of the eight patients with no structural abnormality, in six the marshmallow bolus became impacted in the lower esophagus, and two of these were asymptomatic with impaction; of the two asymptomatic patients, one had normal esophageal motility and the other had a nonspecific esophageal motility disorder. Three of the four symptomatic patients had symptoms referred to the sternal notch; of these three, two had a nonspecific esophageal motility disorder and one had normal esophageal motility. The fourth symptomatic patient had symptoms referred to the neck and had normal esophageal motility. In the remaining two patients, the marshmallow became impacted in the mid esophagus, with symptoms referred to the neck and to the mid chest, respectively; both patients had normal esophageal motility (Fig. 5).

Discussion

The lower esophageal mucosal ring appears as a thin, smooth, circumferential narrowing at the esophagogastric junction with a fixed maximum diameter [1, 2, 10, 11]. The lower esophageal mucosal ring must be differentiated from the muscular ring and from an annular peptic stricture [1]. In 1953, Schatzki and Gary [10] first described the association of the lower esophageal mucosal ring with dysphagia; in a subsequent study, Schatzki [2] showed that the caliber of the ring related to the prevalence of dysphagia. Rings measuring more than 20 mm were rarely symptomatic, whereas those less than 13 mm nearly always caused dysphagia. Rings measuring 14–20 mm were variably symptomatic in about half the patients. Thus, mucosal rings up to 20 mm in caliber need to be detected accurately.

Of the 26 patients with lower esophageal mucosal rings in our study, 21 (81%) complained of solid food dysphagia. Symptoms were provoked in 12 (75%) of 16 patients who had impaction of the marshmallow at their rings; of these 12 patients, 11 (92%) referred their dysphagia upward and seven (58%) had symptoms localized in the neck. These results indicate that the referral of symptoms above the lower chest is common in patients with lower esophageal mucosal rings and emphasize the need to examine the

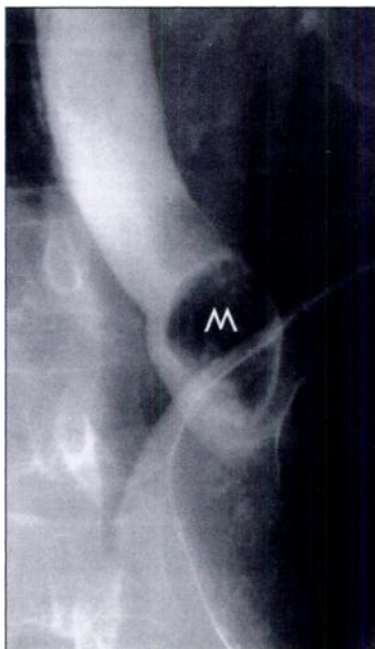


Fig. 4.—55-year-old woman with intermittent solid food dysphagia localized to sternal notch. Barium esophagogram shows marshmallow (M) transiently suspended in esophageal vestibule; no structural abnormality was found at esophagogastric junction.

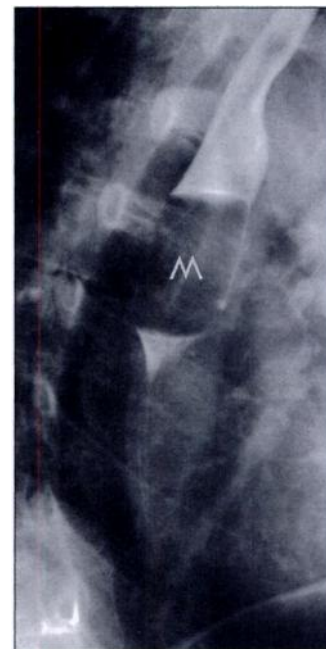


Fig. 5.—53-year-old woman with progressive solid food dysphagia. Barium esophagogram shows transient impaction of marshmallow (M) in mid esophagus, which produced symptoms at that level; no structural or motility abnormalities of esophagus were found.

entire esophagus and esophagogastric region regardless of the level of dysphagia.

All the rings that caused impaction of the marshmallow bolus were 20 mm or less in diameter, which is consistent with previous observations by Schatzki [2]. Impaction occurred in four (66%) of six rings measuring 9–12 mm and in 12 (66%) of 18 rings measuring 13–20 mm. Of the two patients with ring diameters greater than 20 mm, one presented with heartburn without dysphagia and the other had intermittent solid food dysphagia; marshmallow bolus testing did not cause impaction or provoke symptoms in these two patients.

Multiple abnormalities were found in the pharynges of patients with lower esophageal mucosal rings. However, these abnormalities were usually minor and unrelated to the patients' symptoms. None of the patients with cricopharyngeal bars or Zenker's diverticula complained of dysphagia during passage of the marshmallow through the pharyngoesophageal area. Cricopharyngeal bars were present in 12 patients without rings, and only one showed transient impaction of the marshmallow at the pharyngoesophageal level. The prevalence of pharyngeal functional abnormalities increases with age, and many of these abnormalities are not symptomatic [13]. The patients with pharyngeal abnormalities in our study had a mean age of 67 years, and these abnormalities were likely incidental to their presenting complaints.

Previous reports of obstructing lesions in the lower esophagus have found that the level of symptoms is not reliable for predicting the location of the causative lesion [3–6]. Edwards [3] described a large series of patients with achalasia, cancer of the fundus gastricus, and esophageal strictures; in this series, dysphagia was often localized by the patient above the level of the lesion. In particular, symptoms referred to the neck or sternal notch were usually not associated with abnormalities at these levels. Only rarely were symptoms of lesions at the pharyngoesophageal junction referred downward. Our results also indicate that the lower esophageal mucosal ring can often cause symptoms of dysphagia that are referred upward; this finding is similar to other disorders of the lower esophagus.

The radiographic visualization of lower esophageal mucosal rings requires optimum distention of the esophagogastric region; this is best accomplished by having the patient swallow barium suspension rapidly while in the prone oblique position [1, 7, 9, 14]. If adequate distention of the lower esophagus is not

achieved, an abdominal bolster, solid bolus, or iced barium suspension can be used [15]. Mucosal rings that are not shown on the initial radiographic examination using a liquid barium suspension may be detected with a solid bolus; this was observed in only one (4%) of the 26 patients with rings in this series. However, in another study of 63 patients with lower esophageal mucosal rings, nine rings (14%) were detected radiographically only after the use of a marshmallow bolus [16]; in that same study, endoscopy failed to detect 30% of the rings found radiographically, which indicates that mucosal rings and their relationship to dysphagia are best evaluated using radiography.

Solid boluses have been used for esophageal examination for many decades, with the 12.5-mm barium tablet and a marshmallow recommended most often [9, 16–20]. We prefer the marshmallow bolus because its caliber will permit impaction at nearly all symptomatic mucosal rings, whereas using the barium tablet, rings larger than 12.5 mm are not detected. In addition, the marshmallow is deformable and will usually pass through a mucosal ring of smaller size, which imparts a figure-eight appearance to the marshmallow. Unlike when a barium tablet swallowed with water is used, the use of a dilute barium suspension to wash down the marshmallow will show the cause of impaction if it occurs. Recently, Simon et al. [20] compared the 12.5-mm barium tablet with a 20-mm marshmallow bolus for evaluating a variety of structural and functional esophageal abnormalities; these authors confirmed that the marshmallow is a more sensitive and specific means of bolus examination.

In our study, 104 (80%) of 130 patients did not have lower esophageal mucosal rings, yet impaction of the marshmallow was observed in 21 (20%) of these individuals. In five of six patients with strictures, impaction occurred at the level of the stricture. Most other patients with abnormalities other than rings had impaction at levels not related to their structural abnormalities. Esophageal motility disorders were present in some of these patients and likely caused the bolus to remain stationary and simulate impaction. Six (75%) of the eight patients with radiographic examinations with normal findings had marshmallow impaction in the lower esophagus; symptoms were evoked in four of these patients and referred to the sternal notch in three. Studies have shown that esophageal distention can cause pain or a pressure sensation in the chest or upward; this likely explains the symptoms provoked on solid bolus evaluation in some of the pa-

tients without esophageal abnormalities [21–24]. Thus, a minority of patients may show a transient suspension of bolus progression in the esophagus without a causative fixed narrowing, which may evoke symptoms that are referred upward; correlation with the status of esophageal motility is important.

Esophageal motility disorders may be a cause of dysphagia or chest pain [12, 22–24]. In this study, 10 patients with hiatal hernias and no structural esophageal abnormalities had symptomatic marshmallow bolus impaction. Four of these patients likely had impaction because of an esophageal motility disorder; however, the other six patients had symptomatic impaction but normal esophageal motility. Potential explanations for bolus impaction and symptom production in these patients might include bolus size relative to esophageal luminal caliber, minor motility disturbances better shown by esophageal manometry, or individual variations in esophageal sensitivity to bolus movement through the esophagus [21–24].

In summary, the results of this study suggest that symptom referral varies in patients with lower esophageal mucosal rings but will often be upward to the level of the neck. The marshmallow bolus technique is successful in reproducing symptoms in many patients with mucosal rings. Although rings of smaller caliber are more likely to be symptomatic, some patients with rings as large as 20 mm present with solid food dysphagia. A minority of patients with this symptom have an esophageal motility disorder, and the solid bolus is an adjunct to their radiographic evaluation. Marshmallow bolus testing is also useful in patients without a known structural or functional esophageal disorder, because impaction may provide an explanation for their symptoms. In patients with intermittent solid food dysphagia, a careful radiographic examination of the pharynx, esophagus, and esophagogastric regions is needed. Evaluation of the lower esophagus and adjacent stomach is particularly important in patients with symptoms at any level in the chest or neck.

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