

Review Esophagogastric Region and Its Rings

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Considerable controversy and confusion over the anatomy of the esophagogastric region and its associated rings persist. Nevertheless, over the past several decades, a better understanding of the anatomic and functional features of the esophagogastric region has emerged. We will (1) review the anatomy of the esophagogastric region; (2) offer a practical classification of the lower esophageal rings; (3) thoroughly review the lower esophageal mucosal ring; and (4) discuss the radiographic features of these rings and their differential diagnosis.

Anatomy of the Esophagogastric Region

The terminology used to describe the anatomy of the esophagogastric region has been lengthy and often contradictory. Two or three decades ago, a controversy existed over whether the esophagus terminated as one or two sacs before entering the stomach [1-5]. The two-sac theory gained much favor at that time. More recently, however, this concept has been revised, with the modern view being that the lower esophagus ends as a single saccular structure [6-12]. Unfortunately, many different terms have been used to name this saccular structure or parts of it.

In the normal resting state, most of the lower esophageal sac lies above the level of the diaphragmatic hiatus, while a shorter part lies below the hiatus within the abdomen. The two most popular terms that were used to describe these components were the *phrenic ampulla* for the bell-shaped part lying above the diaphragm and the *submerged segment* for the infrahiatal part. The term *esophageal vestibule* also gained favor as a label for the whole lower esophageal sac.

However, many studies have shown that the normal esophagogastric region is not stationary relative to the diaphragmatic hiatus but changes its relation in response to positioning, respiration, and swallowing [7, 9, 12-15]. The diaphragmatic hiatus slides down the esophagus on deep inspiration; also, the lower esophagus moves orad in response to the longitudinal shortening associated with primary esophageal peristalsis. Under these circumstances, the esophagogastric junction approximates the level of the diaphragmatic hiatus, thereby partially or completely obliterating the intraabdominal part of the esophagus.

In view of the above, the division of the esophageal vestibule into the phrenic ampulla and the submerged segment would seem to be somewhat artificial. To avoid confusion, the term *phrenic ampulla* probably should be discarded [16]. However, the concept of the *submerged segment* remains of radiologic value, since its widening or disappearance is indicative of hiatal hernia and often is associated with symptomatic gastroesophageal reflux disease [17-23].

The location of the junction between the lower end of the esophagus and the stomach has been argued extensively. Much of the debate has centered on whether the squamocolumnar mucosal junction, or Z line, can be used as a valid indicator of the esophagogastric junction. Recent anatomic and histologic evidence would

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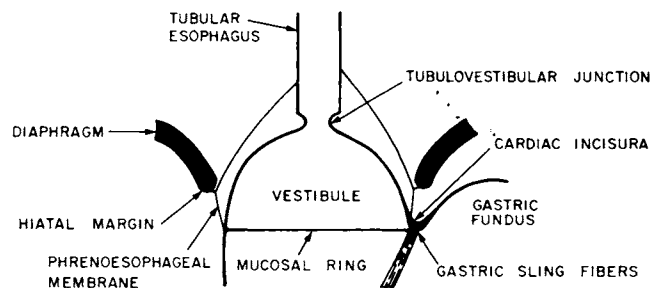


Fig. 1.—Diagram of lower esophageal anatomy with simplification of terminology. Esophageal vestibule is defined by tubulovesibular junction superiorly and by upper margin of gastric sling fibers inferiorly. When present, mucosal ring approximates level of gastric sling fibers and, for practical purposes, demarcates esophagogastric junction. Phrenoesophageal membrane normally has both lower and upper limb, latter inserting near tubulovesibular junction. (Modified from [9].)

suggest, however, that the mucosal transition between the esophagus and stomach is not an acceptable criterion for locating the esophagogastric junction [7–10, 16]. On the other hand, the upper level of the gastric sling fibers is believed to be the most reliable landmark for this junction. These muscle fibers lie within the gastric wall, straddle the cardiac incisura, and demarcate the left lateral margin of the esophagogastric junction. The squamocolumnar mucosal junction normally lies 1–2 cm above the level of the gastric sling fibers.

Another area of controversy has been the existence and nature of a sphincteric mechanism in the esophagogastric region. Several decades ago, the presence of a short, anatomic sphincter in the lower esophagus was widely accepted. This was called the *inferior esophageal sphincter* and was believed to be located at the junction of the tubular and saccular parts of the esophagus [1, 2, 4]. However, numerous manometric and correlative radiologic investigations have refuted this concept. The current view is that a 2–4-cm-high pressure zone exists in the esophagogastric region and represents a physiologic, rather than an anatomic, sphincter [9, 10, 24–27]. This zone has been labeled the *lower esophageal sphincter* and should not be confused with the now defunct inferior esophageal sphincter. The location of the manometric lower esophageal sphincter generally corresponds to that of the esophageal vestibule [10, 12, 24, 26].

Because of this clearer understanding of the anatomy and function of the esophagogastric region, a simplification of the available terminology is warranted [16]. From a practical standpoint, the esophagus consists of a cylindrical tube with a saccular termination. The cylindrical part represents the tubular esophagus, while the saccular end is best labeled the *esophageal vestibule* (fig. 1). The union between these two esophageal segments is the *tubulovesibular junction*, also called the A level [10]. The position of the gastric sling fibers demarcates the *esophagogastric junction*. These respective junctions therefore define the upper and lower boundaries of the esophageal vestibule. The squamocolumnar mucosal line, also called the B level [10], lies slightly above but near the level of the gastric sling fibers.

Although these esophagogastric landmarks are best appreciated morphologically during maximal distension, recognition of their normal function is also important for a thorough understanding of the region. During the resting state, both the tubular esophagus and esophageal vestibule are collapsed, with the lower esophageal sphincter tightly closed due to its normal resting pressure. With swallowing, however, the lower esophageal sphincter segment relaxes and assumes a bulbous configuration that exceeds the diameter of the adjacent tubular esophagus. This bulbous structure represents the distended esophageal vestibule.

Classification of Lower Esophageal Rings

Ringlike constrictions at locations throughout the entire length of the esophagus have been reported. The two prevailing terms used to describe these structures are the *ring* and the *web*. Unfortunately, these names often have been used interchangeably for focal constrictions occurring at any level in the esophagus. This has been a particular problem in differentiating the various ringlike narrowings that are found in the esophagogastric region [28–30].

We restrict the term *esophageal web* to those constrictions that are covered on both their superior and inferior surfaces by squamous epithelium and are located above the level of the tubulovesibular junction. Conversely, the term *esophageal ring* is limited to those narrowings found in the esophagogastric region, occurring predominantly at the upper and lower boundaries of the esophageal vestibule.

Of the many esophageal ring classifications suggested in the past, the one used by Goyal et al. [31] seems to most appropriately integrate current knowledge of the esophagogastric region with the location of the various rings. The three most common ringlike narrowings that can be found in this region are the muscular ring, the mucosal ring, and the annular peptic stricture. The muscular ring occurs at the upper border of the esophageal vestibule, the mucosal ring is located near the lower vestibular border, and the annular peptic stricture typically occurs at the squamocolumnar mucosal line, or virtually the same location as the mucosal ring.

A number of congenital and miscellaneous constrictions also have been described in the esophagogastric region [32–36]. Congenital narrowings, particularly cartilaginous rings, and other narrowings, such as those produced by leiomyoma, neuroma, and muscular hypertrophy, have been reported only rarely. Because of their rarity, these remote causes of lower esophageal narrowing will not be discussed further.

Lower Esophageal Mucosal Ring

The lower esophageal mucosal ring is the most common ringlike narrowing occurring in the esophagogastric region. Despite numerous reports, debate continues over the exact location and pathogenesis of the mucosal ring. Indeed, it remains uncertain whether the mucosal ring is one distinct structure or one of a group of similar-appearing structures having different origins.

Historical Review

In 1944, Templeton [37] first illustrated annular indentation at the lower end of the esophagus. This was followed by a number of reports describing similar notching in the esophagogastric region [38–40]. At that time, the presence of these lower esophageal notches was believed to be an uncommon occurrence of no clinical significance.

In 1953, however, Ingelfinger and Kramer [41] reported the association of esophageal ring with dysphagia. Independently in the same year, Schatzki and Gary [42] also described the same association and introduced the term lower esophageal ring, which soon became known in common parlance as the *Schatzki ring*. A flood of publications succeeded these two original reports, further verifying the importance of the lower esophageal ring as a cause of dysphagia [43–46].

Pathogenesis and Location

Numerous theories have been proposed to explain the origin of the lower esophageal mucosal ring [31]. Early proposals concentrated on developmental, anatomic, or functional explanations [39–45, 47, 48]. However, the theory of inflammation has gained the widest acceptance [11, 31, 49–54]. This theory suggests that the mucosal ring is part of the spectrum of reflux esophagitis and represents a thin, annular peptic stricture. However, the evidence for a relation between the mucosal ring and gastroesophageal reflux remains unclear. Currently, the main competing theory is that the lower esophageal ring is a transverse mucosal fold of noninflammatory origin [7–9, 15, 16].

The exact location of the lower esophageal mucosal ring has been debated for several decades. The most widely accepted notion is that the ring occurs at the squamocolumnar junction. Indeed, most pathologic reports have described the presence of squamous epithelium covering the upper surface of the ring and columnar epithelium on its undersurface [52, 55–60]. Occasional reports, however, have shown such rings to be covered totally by either squamous or columnar mucosa [60–62]. It remains uncertain whether these rings covered by only one type of mucosa are etiologically identical to those having a mixed mucosal covering.

Manometric, radiologic, and peroral biopsy correlations have produced contradictory results in attempting to localize the lower esophageal mucosal ring [24, 63–66]. These studies have placed the mucosal ring variously above, at, or below the squamocolumnar junction. Unfortunately, much of these data are invalid because of failure to appreciate the normal orad movement of the esophagogastric region with swallowing. During primary esophageal peristalsis, the lower esophagus shortens and moves upward. This movement makes it unlikely that exact anatomic correlations were made during many of these investigations [12, 58].

Radiographic Appearance

From a practical standpoint, the lower esophageal mucosal ring demarcates the lower end of the esophageal vestibule

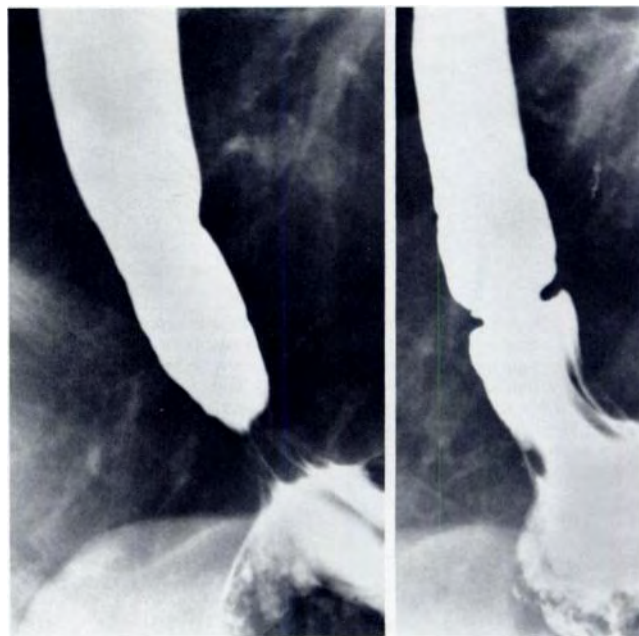


Fig. 2.—Patient with intermittent dysphagia: esophageal manometry and endoscopy were normal. A, Normal initial esophagram. B, Esophagram 2 days later. Mucosal ring 12 mm in caliber. Production of hiatal hernia on second examination permitted distension of esophagogastric region beyond caliber of ring.

and its union with the stomach. According to present opinions, the ring occurs at or just below the squamocolumnar mucosal junction. The ring is seen radiographically only when it is located at or displaced above the esophageal hiatus of the diaphragm (fig. 2).

When visible, the mucosal ring appears as a thin, transverse structure encircling the lower end of the esophageal vestibule (fig. 3). The margins of the ring are smooth and symmetrical. Its maximum internal caliber is fixed and reproducible during the same examination. To see the ring, the esophagogastric region must be adequately distended [30, 42, 67]. The degree of distension needed will depend on the actual caliber of the ring. Rings with broad openings are easily missed radiographically if distension is poor during the examination. The prone position with the patient performing a Valsalva maneuver is optimal for demonstrating mucosal rings (fig. 4).

Clinical Significance

The reported radiographic incidence of the lower esophageal mucosal ring has varied considerably from 0 to 32% [2, 45, 68–72]. This variation is best explained by the techniques used to demonstrate the ring and the age of the patients examined. These rings rarely will be seen if the radiographic method does not include a prone examination of the esophagogastric region. The incidence also increases with age, being extremely low in those under 30 years and much higher in patients over 50 [72].

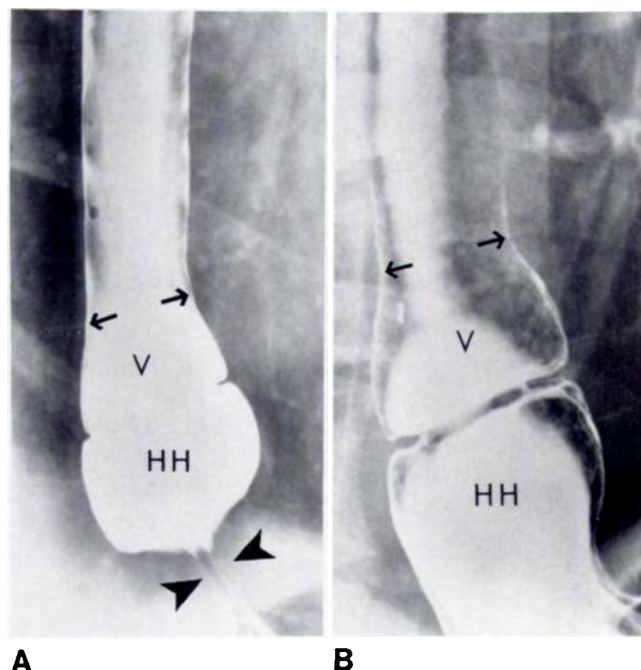


Fig. 3.—Two patients. **A**, Widely patent mucosal ring projects 3 cm above pinchcock effect of diaphragmatic hiatus (arrowheads). **B**, Double-contrast view of esophagogastric region in another patient. Smooth, symmetric mucosal ring. Arrows = tubulovesibular junction; V = vestibule; HH = hiatal hernia.

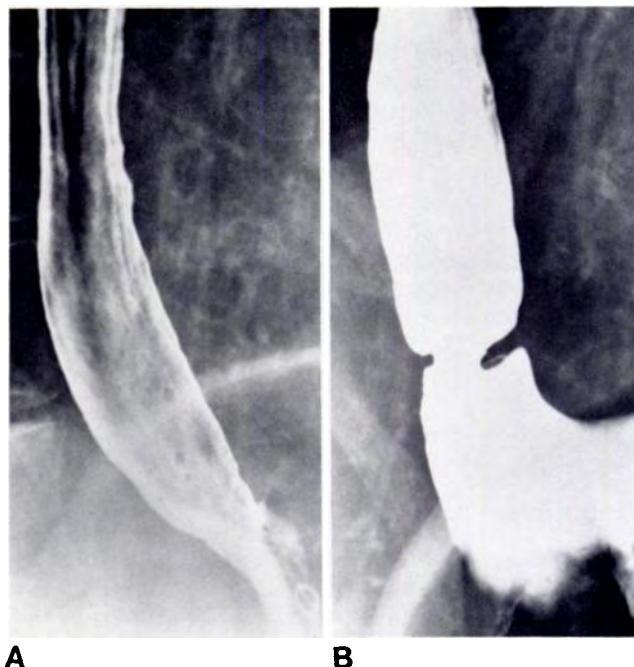


Fig. 4.—Patient with dysphagia. **A**, Upright double-contrast view of lower esophagus. No abnormalities. **B**, Prone full-column view. Mucosal ring only 8 mm in diameter (verified endoscopically).

Most patients with lower esophageal mucosal rings are asymptomatic. The clinical significance of the mucosal ring depends on its relation to hiatal hernia, on its internal caliber, and on its possible confusion with other annular narrowings in the esophagogastric region. Since the mucosal ring demarcates the junction of the esophageal vestibule and the stomach, its presence above the diaphragmatic hiatus has been used as a sign of sliding hiatal hernia. Some have argued, however, that the ring must be situated at least 1–2 cm above the level of the diaphragmatic hiatus to be used as a valid sign of herniation [12, 16]. The reason for this criterion relates to the normal oral motion of the esophagogastric region with swallowing and the concept that slight "physiologic herniation" is normal in many individuals, especially as they age.

A more important clinical consideration is the relation of dysphagia to the internal caliber of the mucosal ring [73–75]. A widely patent mucosal ring more than 20 mm in caliber is rarely symptomatic. Conversely, rings that are under 13 mm in diameter are nearly always symptomatic. Rings 13–20 mm in caliber may or may not cause dysphagia depending, in part, on the eating habits of the patient. Episodic dysphagia to solid food is the most common complaint. Impaction of a food bolus at the ring also may occur, often associated with severe chest pain [76].

Most mucosal rings tend to remain static in size. However, about one-fourth of asymptomatic and one-third of symptomatic rings decrease in caliber if followed for at least 5 years or more [73]. It is extremely rare for these rings to spontaneously enlarge. Conservative treatment often is successful

and is based on explaining the relative benignity of the condition to the patient and instructing patients in proper mastication of their food. If more aggressive therapy is needed, endoscopic rupture of the ring or esophageal dilatation using bougienage or pneumatic devices usually is successful (fig. 5). Surgical removal rarely is indicated.

Differential Diagnosis

The lower esophageal mucosal ring also must be differentiated from other narrowings that may occur in the esophagogastric region. These most commonly include the muscular ring and the annular peptic stricture. While carcinoma may cause narrowing of the lower esophagus or esophagogastric junction, it rarely is confused with the mucosal ring.

Muscular Ring

The muscular ring occurs at the tubulovesibular junction and is covered totally by squamous epithelium (fig. 6). The origin of the muscular ring is uncertain. However, muscular thickening in this location has been shown to occur, suggesting that these rings may represent focal muscle hypertrophy [1, 4]. Radiographically, the muscular ring appears as a broad, smooth narrowing at the upper end of the esophageal vestibule [10, 77]. Unlike the mucosal ring, the muscular ring varies in caliber on the same examination and may disappear completely on maximum distension of the esophagus (fig. 7).

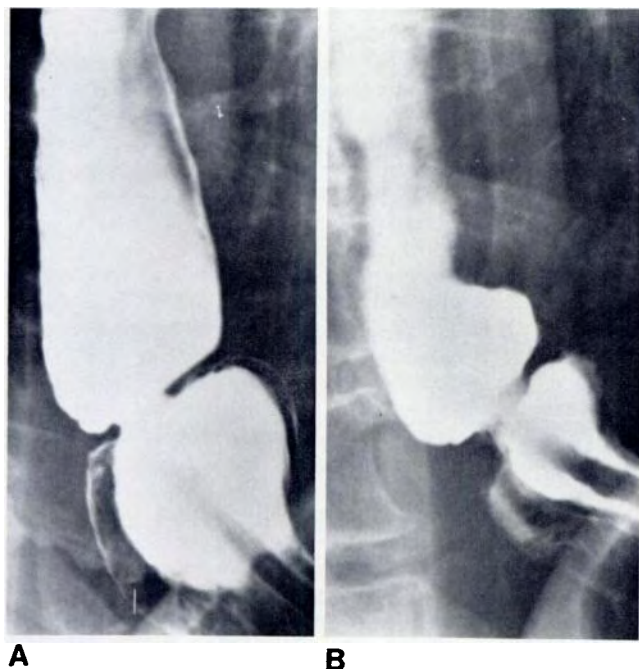


Fig. 5.—**A**, Symptomatic mucosal ring, 10 mm in caliber, before treatment. **B**, Slight irregularity of margins of ring after esophageal bougienage without significant change in caliber. However, symptoms were relieved. Lack of caliber change radiographically after successful forceful dilatation of mucosal ring has been typical observation in our experience.

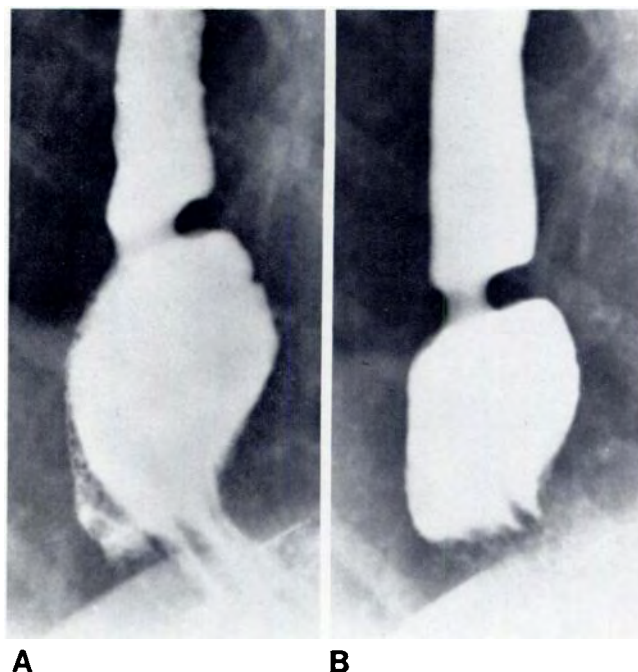


Fig. 7.—Broad, smooth narrowing of muscular ring at tubulovesicular junction. Caliber of ring changes from 12 mm (**A**) to 6 mm (**B**) on two views.

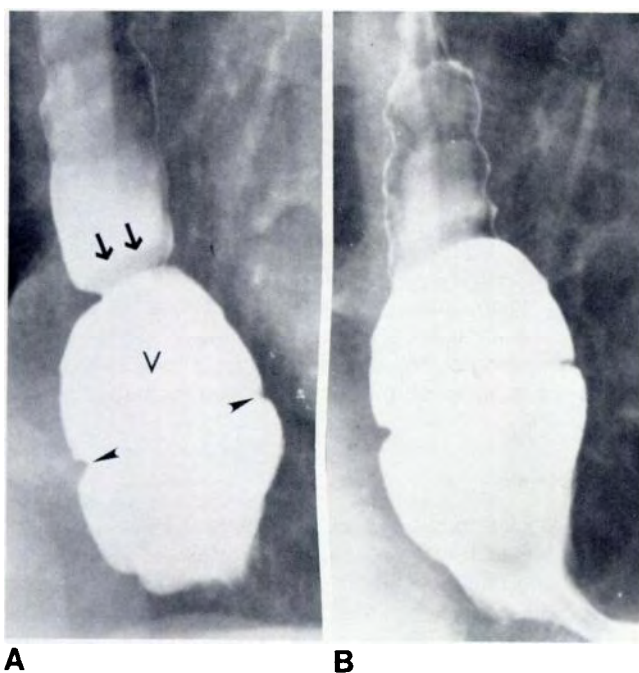


Fig. 6.—**A**, Esophageal vestibule (V) is demarcated superiorly by muscular ring (arrows) at tubulovesicular junction and inferiorly by mucosal ring (arrowheads) at esophagogastric level. **B**, Moments later, muscular narrowing disappears, while mucosal ring remains static in appearance.

Muscular rings rarely cause symptoms [31]. Dysphagia is the most common associated complaint and is indistinguishable from that produced by a mucosal ring. Prominent muscular rings seem to be seen more often in patients with hiatal hernia, gastroesophageal reflux, and possibly in those with esophageal motor disorders. The significance of these associations, however, is unknown. Treatment of the symptomatic muscular ring should be conservative. The nature of the problem needs to be thoroughly explained to the patient. If necessary, esophageal bougienage is often helpful. Operative treatment has been performed only rarely.

Annular Peptic Stricture

Peptic esophagitis may produce an inflammatory fibrosis leading to stricture formation. Most peptic esophageal strictures are thick vertically and have a smoothly or irregularly tapered appearance. However, about 15% of peptic strictures have a narrow, annular configuration that must be differentiated from the various lower esophageal rings [78].

For several reasons, differentiation of an annular peptic stricture from the mucosal ring is more difficult than distinguishing between mucosal and muscular rings. The peptic inflammatory process starts at the squamocolumnar junction in a location similar to that of the mucosal ring. Furthermore, the peptic stricture is also a fixed structure that is best seen on maximal distension of the esophagogastric region.

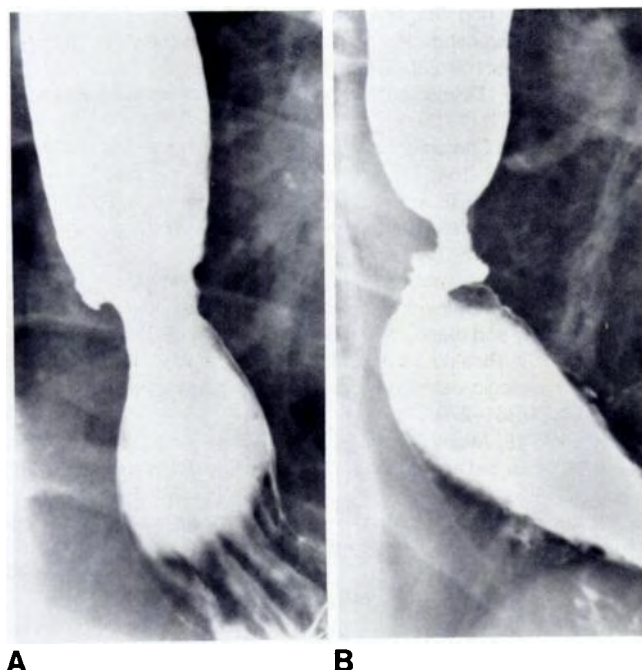


Fig. 8.—A, Slightly irregular peptic stricture more than 8 mm in vertical thickness. B, Peptic stricture showing irregular, eccentric narrowing.

Radiographically, the annular peptic stricture is usually thicker than the mucosal ring and often will show some irregularity and asymmetry (fig. 8). Conversely, mucosal rings are generally smooth and thin, typically measuring less than 3–4 mm in their vertical thickness. Other evidence of reflux esophagitis, such as thickened esophageal folds or serration of the esophageal margin, often is seen in conjunction with peptic stricture but is seen less frequently in association with a lower esophageal mucosal ring [21, 78–82].

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