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The Esophagus

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Abstract

Original investigations and descriptions of the radiographic findings and techniques of evaluation of the esophagus and esophagogastric junction were made at The Mount Sinai Hospital by Drs. Bernard S. Wolf and colleagues in the third quarter of the 20th century. These included basic descriptions of peptic ulceration of the esophagus, the gastric lined esophagus, definitions of hiatus hernia, terminology of the esophagogastric junction, use of the barium pill and correlations of cineradiology with manometry. **Key Words:** Esophagus, radiology, motility, esophagitis, hiatus hernia, esophagogastric junction.

DR. BERNARD S. WOLF, chief of Radiology at The Mount Sinai Hospital from 1949–1977, and his colleagues made original investigations and descriptions of the radiographic findings in many esophageal diseases. In the 1950s, advances in fluoroscopy and cineradiography techniques allowed more detailed study of the esophagus and its motility, and allowed correlative study with esophagoscopy and manometry.

An increase in clinical interest in diseases of the esophagus, particularly in benign inflammatory conditions associated with hiatus hernia, led them to refine and amplify special procedures, maneuvers and technical factors designed to demonstrate such lesions. The consistency of the barium used for the examination of the esophagus was altered. Recommendations were made for patient positioning and the projections for routine studies and those for demonstrating particular diseases (1). They used a radiolucent bolster during continuous drinking in the prone right anterior oblique (RAO) position, to demonstrate minimal herniation of the esophagus and maximal size of the hernia (1, 2).

Various methods for demonstrating reflux were in use. However, Wolf's group recommended a more physiologic evaluation, with the patient in a moderate supine Trendelenburg position (1). It was noted that a fair amount of air was swallowed along with the barium, and by continued drinking through the straw after completion of a cup of barium, additional swallowed air would lead to a "double contrast" effect. This was the basis for the primary double contrast study in use today (1).

Peptic Esophagitis

In 1934, Winkelstein described to the annual meeting of the American Medical Association (AMA) a new clinical entity which he called peptic esophagitis (3). His five cases all had symptoms typical of the recently established disease of peptic ulcer of the esophagus, especially pain and dysphagia, but radiology showed only irregular narrowing, esophagoscopy only congestion and inflammation, and biopsies only acute and/or chronic inflammation; there were no ulcers. Three of the five had a previous duodenal ulcer, one a previous esophageal ulcer and one a subsequent incisural gastric ulcer. Acidities were high. All five responded to ulcer therapy and Winkelstein attributed the peptic esophagitis to erosion by gastric juice rising into the lower part of the esophagus. Similar cases were reported at the same time both in Europe and elsewhere in the U.S. The presence of a hiatus hernia was not emphasized in the 1930s, and it was only in the

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1940s that Allison attributed the esophagitis to reflux with hiatus hernia.

The 1950s saw the first basic radiologic descriptions of peptic ulceration of the esophagus (4–8). In 1954, Winkelstein, Wolf, Som and Marshak recognized that the triad of duodenal ulcer, hiatus hernia and peptic esophagitis is of special clinical significance (5). In 1957, Winkelstein presented twenty cases: "Peptic esophagitis probably commences with a more or less continual transcardial reflux from the stomach of a highly acid peptic secretion. This reflux may result from the hypersecretion associated with the duodenal ulcer or from the unexplained decrease in the tone of the cardiac sphincter. Perhaps the characteristic nocturnal hypersecretion with the patient in the horizontal position leads to prolonged bathing of the lower esophagus by the highly acid gastric contents" (8). Complications included stenosis, massive hemorrhage and perforation. Although Winkelstein continued to distinguish his peptic esophagitis from reflux esophagitis, it is the latter term or the more inclusive "gastro-esophageal reflux disease" which now prevails.

The radiographic findings in peptic esophagitis and peptic ulceration in association with gastric lined esophagus (Barrett epithelium) were described in detail in subsequent papers (9, 10). It had been stated previously that esophagitis occurs in one-half to three-quarters of patients with sliding hiatus hernia and that radiologic findings are frequently absent. Wolf and his colleagues identified subtle abnormalities that would suggest the presence of mild esophagitis, such as mild functional disturbances with inefficient peristaltic stripping action, mild nondistensibility and subtle fold and mucosal abnormalities.

Hiatus Hernia and the Esophagogastric Junction

The radiographic anatomy of this region was studied extensively and defined by Wolf and colleagues (2, 11–21). These descriptions were supplemented by many illustrations which captured the dynamic changes observed fluoroscopically in this region (2, 11–21). The terminology of the esophagogastric junction had long been disputed and correlations with anatomical and surgical findings were unsatisfactory. They were able to correlate radiographic observations and manometric measurements, and classified the rings seen in the distal esophagus as A rings (contraction) and B rings (the B rings representing the esophagogastric [EG] or squamomucosal junction). They then defined and redefined the radiographic diagnosis of sliding hiatus hernia.

Conclusions reached by studying large numbers of patients helped to clarify confusing terminology and correlated radiographic findings with manometric and autopsy descriptions of the EG junction. By 1958, it was possible to make the following authoritative conclusions (12) (Fig. 1):

1. The terminal two or three centimeters of the esophagus may contract and relax as a unit independently of the adjacent portions of the esophagus and stomach. Lerche's term, the vestibule (22), may be applied to this segment.

2. The vestibule as a single distensible unit can be observed only in the presence of a direct hernia, since the distal half of the vestibule normally is located in and below the diaphragm and is therefore limited in distensibility by extrinsic factors.

3. Notches or a static ring may be seen at the distal margin of the vestibule when the vestibule is herniated and distended. Since these notches indicate the junction between the vestibule and the stomach, their presence above the diaphragm is indicative of a hiatus hernia.

4. Notches or a complete ring may also be seen at the proximal margin of the vestibule. A ring in this location may show independent contractile activity and therefore may be equated with the inferior esophageal sphincter of Lerche. However, except perhaps during regurgitation, localized sphincter activity in this area is less commonly seen than contraction of the vestibule as a whole. The description of Lerche emphasized remarkable distensibility of the vestibule rather than the more important functional aspect of contractility.

5. The "high pressure zone" or "gastro-esophageal sphincter" or "vestibular sphincter" described as a result of pressure studies in the esophagogastric region corresponds to the vestibule as described above.

6. In the studies reported, there was little or no evidence for the presence of a discrete sphincter at the distal margin of the vestibule, that is, at the cardia. It is possible, however, that the notches and ring seen

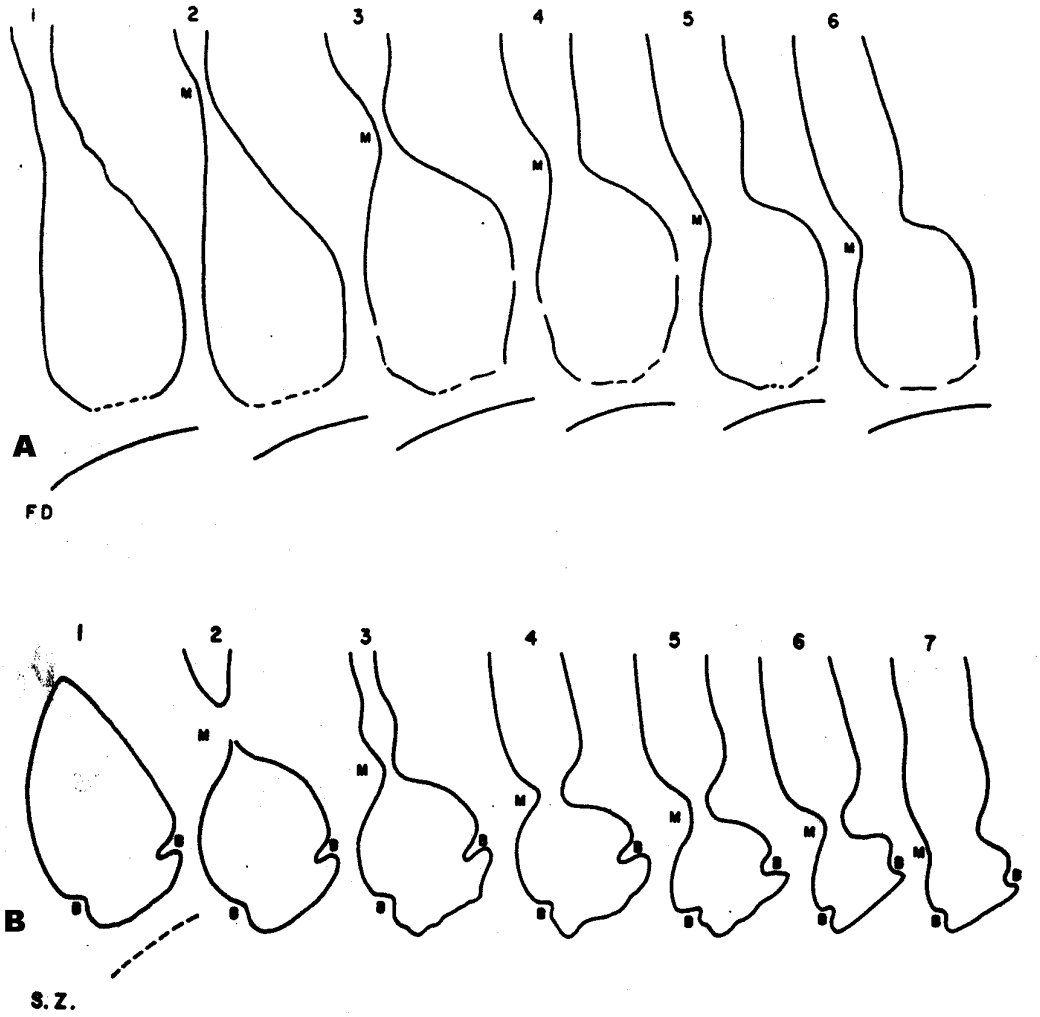

Fig. 1. The Gastroesophageal Vestibule. Reproduced with permission from *The Journal of The Mount Sinai Hospital* (12).

A. Tracings from a movie sequence showing the formation and change in size of the phrenic ampulla during maintained deep inspiration. The elongated constriction (M) represents the stripping peristaltic wave which is slowed up in the distal esophagus as it progresses into the ampullary formation and displaces barium proximally. Note that the width of this constriction increases as it progresses distally and that the wave stops about 3 cm above the diaphragm. The presence of a small hernia in this patient is not evident in these tracings but was suspected from other views. Faint notches about 2 cm above the diaphragm were occasionally seen in fleeting fashion.

B. In this patient, opaque material was injected into the wall of the esophagus down to the esophagogastric mucosal junction, confirming the presence of a small hiatus hernia beginning at the BB ring. Sequence of events during deep inspiration and the formation of the phrenic ampulla demonstrate that the BB ring remains unchanged in location while the constriction associated with the peristaltic wave (M) travels distally but stops 1 cm or so above the B level. Note complete cut-off at level of hiatus (dashed line in frame 1) despite the presence of a hernia.

in this area result from the existence of the specialized muscle bundles designated in the anatomical literature as the cardiac sphincter or the constrictor cardiae. The term "sphincter," however, appears to be a misnomer.

7. The beginning of gastric mucosa or rugae corresponds sufficiently well to the level of the so-called distal notches and ring seen on roentgen examination to make these equivalent criteria for the junction of esophagus and stomach.

8. The term "phrenic ampulla" was introduced into the roentgen literature by Templeton to apply to the sac-like collection of barium trapped above the diaphragm in deep inspiration. The phrenic ampulla, however, is not a unique structure since it

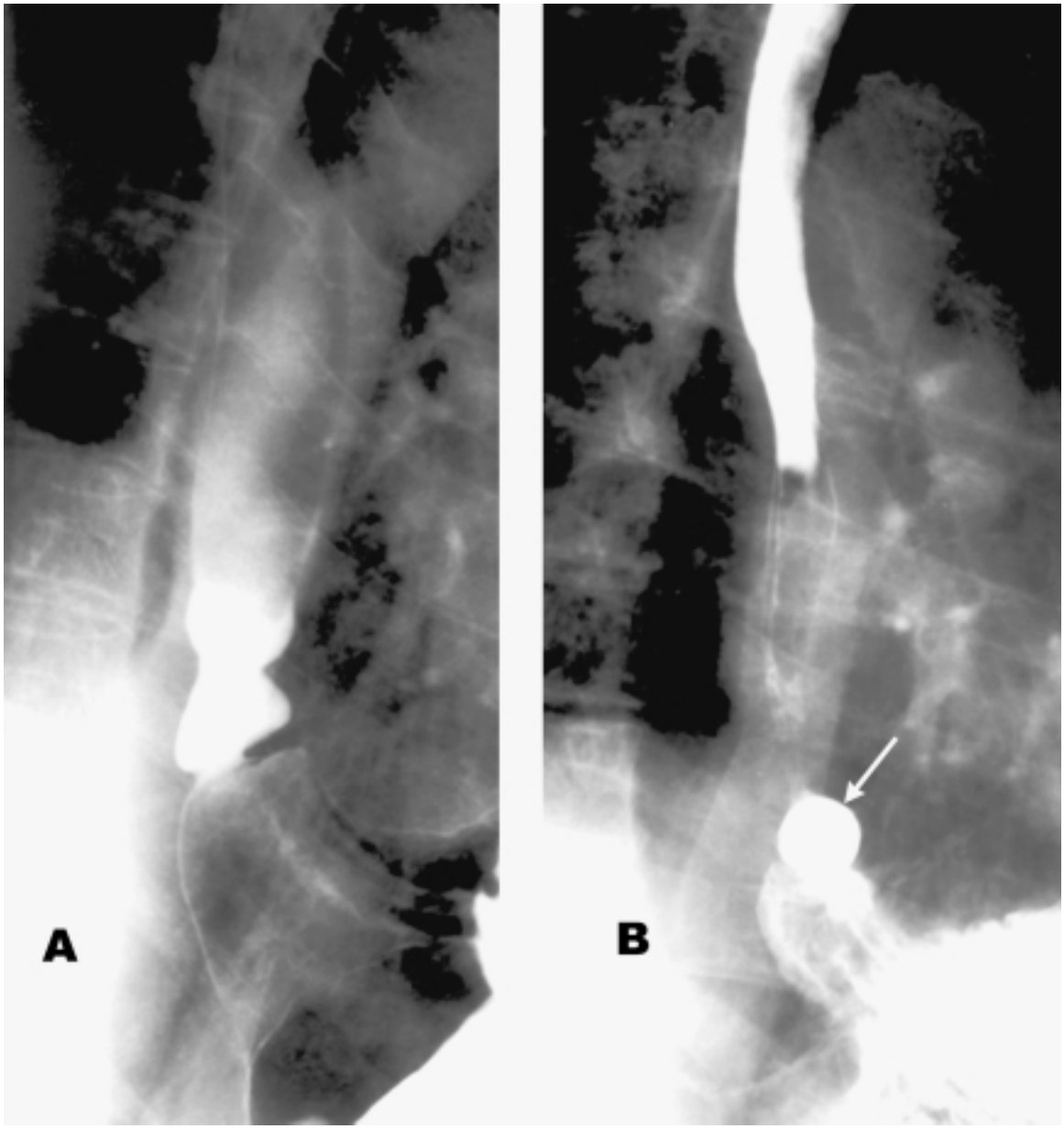

Fig. 2. Barium esophagram demonstrates (A) a hiatus hernia with A and B rings and (B) impaction of the barium pill (arrow) at the level of the ring. Symptoms could therefore be attributed to the ring.

has a variable size determined by the pinchcock action of the diaphragm and the progress of the primary peristaltic wave. In the presence of a small direct hernia, the phrenic ampullae include the vestibule and the herniated portion of the stomach. The term "phrenic ampulla" as used by radiologists should not be confused with the original anatomical description, which presumably included features currently ascribed to the vestibule.

The first report of a B ring treated endoscopically was made in 1960 by Som, Wolf and Marshak (23). The patient had a symptomatic B ring, measuring 1 cm in diameter as measured in comparison with an impacted 1.25 cm barium pill. A 1.6 cm (48F) esophagoscope was passed and through it an esophageal forceps with right angle punch distally. The ring was grasped between the cutting jaws of the punch and severed. The patient had successful relief of symptoms.

The Barium Pill

In 1956, Wolf reported the use of a half inch barium tablet to detect minimal esophageal stric-

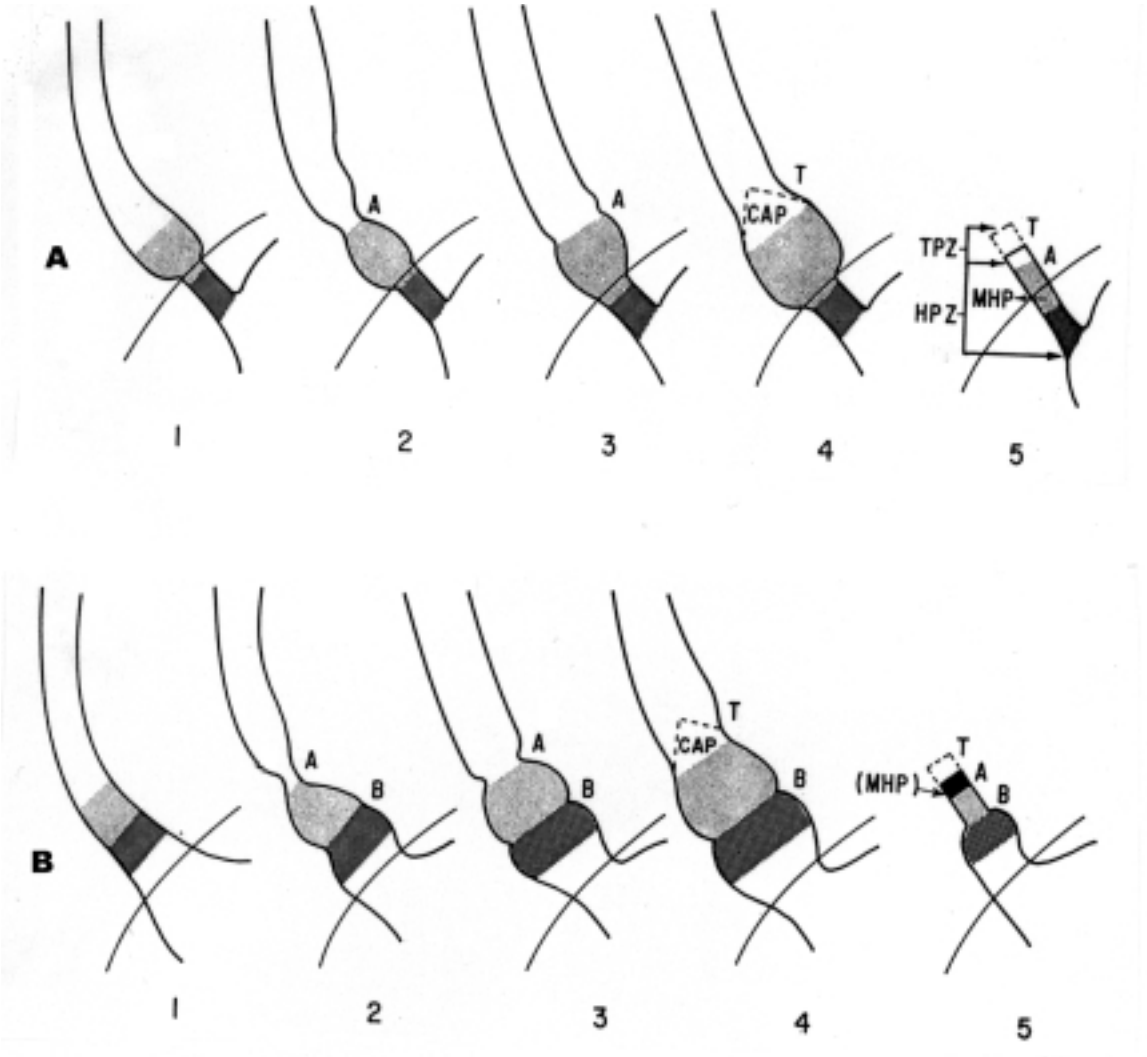

Fig. 3. The inferior esophageal sphincter. Reproduced with permission from the *American Journal of Roentgenology* (28).

A. Diagrammatic representation of vestibular and cardiac canal segments under normal circumstances in filled and empty phases. The vestibular segment is dotted and the cardiac canal cross-hatched. The proximal margin of the vestibule and the site of a potential functional ring is indicated by A. The cap in Panel 4 indicates the appearance in the transitional zone when the peristaltic wave reaches this area. Panel 5 represents the resting state. The transitional pressure zone (TPZ, unshaded) is shown as extending from the end of a tubular esophagus proper to the A level. The sharp distinctions in the resting phase diagram do not actually exist. The high pressure zone (HPZ) extends from the A level to the cardiac orifice. The peak or maximum pressure (MHP) of this zone is below the level of the hiatus.

B. Diagrammatic representation of the vestibule and "cardiac canal" in hiatal herniation. The A and B levels are indicated. The dotted region represents the vestibule and the cross-hatched regions the incompetent persistently dilated cardiac canal. The sling fibers which normally contract completely to form a short tubular segment now act as if they were part of the fundus of the stomach. Panel 5 shows diagrammatically the possibility that, in some cases, a discrete zone of resting, or maximum, high pressure zone may appear corresponding to an A ring. Pressure at this site may equal or exceed the maximum of the normal HPZ. The resting pressure in the vestibule itself may be somewhat higher than or equal to fundic pressure. In other cases, there is no region between fundus and tubular esophagus in which resting pressure exceeds fundic pressure, i.e., the cardiac canal and vestibule are incompetent and no compensatory A ring is present.

tures (24, 25). These tablets are often referred to as "Wolf pills." The assumption was that if a tablet of this diameter passes through the esophagus, dysphagia is not likely to be of an obstructive basis. The diameter of 1.25 cm was selected to correspond with the diameter of a 36F esophagoscope. The pill is of use in patients who complain of difficulty in swallowing but in whom no apparent or definite abnormalities are identified by conventional methods, and to confirm that findings such as rings or apparent strictures are indeed responsible for symptoms (Fig. 2). The pill is shaped so that obstruction is not increased even though the tablet may be prevented from passing. If obstruction is present and the pill is unable to pass through a stricture or a ring, it will disintegrate within 15–20 minutes. The pill is also helpful in identifying hypopharyngeal or cervical esophageal webs that may be overlooked in conventional studies. If a pill is impacted at that level, it is usually regurgitated after a short interval.

Motility Studies

Working in conjunction with the gastroenterologists, primarily Dr. Bernard R. Cohen, correlations with cineradiology and manometry of the pharynx, hypopharynx and esophagus were made (14, 16, 19, 26–28). More detailed and more physiologic understanding of the radiographic findings were possible using these techniques (Fig. 3). In 1960, intraesophageal pressure determinations were performed and correlated with the radiographic findings during the swallowing of barium using modifications of previously described techniques (14). The findings demonstrated that the junction of the phrenic ampulla and the narrow or "empty" segment in barium filling of the esophagus corresponds to the position of the hiatus and that the junctional segment therefore lies entirely within the abdomen. Refinements in the technique and additional observations were subsequently made, and a series of pressure inversion points were identified during the course of inspiration which corresponded to the posterior region of the physiologic hiatus (16). Manometric features were then correlated with the cineradiographic findings at the esophagogastric junction in patients with hiatal hernias and rings (18, 26–29). Clinical applications of esophageal motility studies and the radiologist's role in the evaluation of patients with heartburn evolved from these physiologic-roentgenographic studies (30, 31).

Conclusions

The radiographic techniques described above and the barium pill are still in wide use today, as are the definitions and terminology of the esophagogastric junction.

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