Hiatus hernia

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INTRODUCTION

Hiatus hernia is a frequent finding by both radiologists (image 1) and gastroenterologists. However, estimates of the prevalence of hiatus hernia vary widely due to inconsistencies in identifying small sliding hiatal hernias. There is also confusion regarding the normal function of the gastroesophageal junction and the clinical implications of a hiatus hernia.

This topic will review the pathophysiology, classification, clinical manifestations, diagnosis, and management of a hiatus hernia. The surgical management of paraesophageal hernia and the management of gastroesophageal reflux disease are discussed separately. (See "Surgical management of paraesophageal hernia" and "Medical management of gastroesophageal reflux disease in adults" and "Approach to refractory gastroesophageal reflux disease in adults".)

ANATOMY AND PHYSIOLOGY OF THE ESOPHAGOGASTRIC JUNCTION

The distal end of the esophagus is anchored to the diaphragm by the phrenoesophageal membrane, formed by the fused endothoracic and endoabdominal fascia. This elastic membrane inserts circumferentially into the esophageal musculature, very close to the squamocolumnar junction, which resides within the diaphragmatic hiatus.

This configuration is altered during swallow-initiated peristalsis, a sequenced contraction of both the longitudinal and circular muscle responsible for bolus propulsion through the

esophagus [1]. With contraction of the esophageal longitudinal muscle, the esophagus shortens and the phrenoesophageal membrane is stretched; its elastic recoil is then responsible for pulling the squamocolumnar junction back to its normal position following each swallow. This is, in effect, "physiologic herniation," since the gastric cardia tents through the diaphragmatic hiatus with each swallow (figure 1) [2].

The globular structure seen radiographically that forms above the diaphragm and beneath the tubular esophagus during peristalsis is termed the phrenic ampulla; it is bounded from above by the distal esophagus and from below by the crural diaphragm (figure 2) [3]. Physiologically, the phrenic ampulla is the relaxed, effaced, and elongated lower esophageal sphincter (LES) [4]. Emptying of the ampulla occurs between inspirations in conjunction with re-lengthening of the esophagus and contraction of the LES [4,5].

The repetitive stress of swallowing, as well as that associated with abdominal straining and episodes of vomiting, subject the phrenoesophageal membrane to substantial wear and tear, making it a plausible target of age-related degeneration. Another potential source of stress on the phrenoesophageal membrane is tonic contraction of the esophageal longitudinal muscle induced by gastroesophageal reflux and mucosal acidification [6].

Aside from its antegrade propulsive function, the esophagogastric junction (EGJ) also serves to minimize reflux. This is accomplished by a complex valvular mechanism, the function of which is partly attributable to the esophagus, partly to the stomach, and partly to the crural diaphragm [7]. The esophageal element has been extensively analyzed and consists of the LES, a 2-cm segment of tonically contracted smooth muscle.

- The proximal margin of the LES extends up to and a short distance proximal to the squamocolumnar junction.
- The distal margin of the LES is more difficult to define, but meticulous three-dimensional reconstructions suggest that the "circular" muscle of the LES is actually a pair of opposing spirals that terminate as the gastric sling fibers create a noose-like myoarchitecture at the EGJ and establish the angle of His (figure 3) [8].
- Surrounding the LES at the level of the squamocolumnar junction is the crural diaphragm, composed mainly of the right diaphragmatic crus [8].

Physiologic studies have demonstrated that diaphragmatic contraction augments EGJ pressure, in essence serving as an external sphincter [9]. Furthermore, if the EGJ is defined as either the end of the LES or the point at which the tubular esophagus joins the saccular stomach, there are normally about 2 cm of tubular esophagus within the abdomen [10].

DEFINITION

Hiatus hernia refers to herniation of elements of the abdominal cavity through the esophageal hiatus of the diaphragm.

CLASSIFICATION

Hiatus hernias are broadly divided into sliding and paraesophageal hernias (figure 4 and image 2). The most comprehensive classification scheme recognizes four types of hiatus hernia.

Type I: Sliding hernia — A type I or sliding hiatus hernia is characterized by the displacement of the esophagogastric junction (EGJ) above the diaphragm. The stomach remains in its usual longitudinal alignment and the fundus remains below the EGJ.

Type II, III, IV: Paraesophageal hernias — A paraesophageal hernia is a true hernia with a hernia sac composed of peritoneum and characterized by an upward dislocation of the gastric fundus through a focal defect in the phrenoesophageal membrane [11].

- Type II hernia results from a localized defect in the phrenoesophageal membrane where the gastric fundus serves as a lead point of herniation, while the EGJ remains fixed to the preaortic fascia and the median arcuate ligament (figure 4) [12].
- Type III hernias have elements of both types I and II hernias and are characterized by both the EGJ and the fundus herniating through the hiatus. The fundus lies above the EGJ (image 3).
- Type IV hiatus hernia is associated with a large defect in the phrenoesophageal membrane and is characterized by the presence of organs other than the stomach in the hernia sac (eg, colon, spleen, pancreas, or small intestine) (image 4).

EPIDEMIOLOGY

It is estimated that greater than 95 percent of hiatus hernias are type I (sliding), with type II, III, and IV (paraesophageal) hernias accounting for approximately 5 percent [13]. Of the paraesophageal hernias, it is estimated that more than 90 percent are type III and the least prevalent are type II. Estimates of prevalence of a type I hiatus hernia in the adult population in

North America vary widely from 10 to 80 percent, largely because of inconsistencies in distinguishing a small sliding hernia from a "generous" phrenic ampulla.

ETIOLOGY

Although the etiology of most hiatal hernias is speculative, trauma, congenital malformation, and iatrogenic factors have been implicated in some patients with a type I (sliding) hiatus hernia. Type II, III, and IV (paraesophageal) hernias are a recognized complication of surgical dissection of the hiatus and occur during antireflux procedures, esophagomyotomy, or partial gastrectomy.

PATHOPHYSIOLOGY

Type I: Sliding hernia — Type I hiatus hernia results from progressive disruption of the esophagogastric junction (EGJ), first with loss of the intra-abdominal length of the esophagus, then with progressive widening of the hiatus and herniation of the gastric cardia (figure 5) [14,15]. Widening of the muscular hiatus and circumferential laxity of the phrenoesophageal membrane allows a portion of the gastric cardia to herniate upward [15]. A sliding hernia does not have a hernia sac and slides into the chest since the EGJ is not fixed inside the abdomen. The phrenoesophageal membrane remains intact, albeit stretched, and the hernia is contained within the posterior mediastinum (figure 4 and image 2).

- **Mechanism of gastroesophageal reflux in type I hiatus hernia** — Endoscopic and radiographic studies suggest that 50 to 94 percent of patients with gastroesophageal reflux disease (GERD) have a type I hiatus hernia as compared with 13 to 59 percent of individuals without GERD [13,16]. The likelihood of GERD increases with anatomic compromise of the EGJ (figure 5) and size of the hiatal hernia. Type I hiatus hernia impacts on reflux both by affecting the competence of the EGJ in preventing reflux and in compromising the process of esophageal acid clearance once reflux has occurred. (See "Pathophysiology of reflux esophagitis".)

- **EGJ competence** – A key function of the EGJ is to limit the reflux of gastric contents, including gastric acid, into the esophagus. Some degree of reflux is necessary to facilitate gas venting (belching) and vomiting, but with EGJ incompetence there is excessive reflux of gastric acid into the esophagus leading to reflux symptoms and/or reflux esophagitis. EGJ incompetence is attributable to both anatomical and physiologic factors. The key physiologic factor is lower esophageal sphincter (LES) hypotension. The key anatomic

factor is the degradation of the EGJ (figure 5). This is associated with loss of the intra-abdominal segment of the esophagus, which widens the angle of His and disables the "flap valve" mechanism wherein increased intragastric pressure compresses the subdiaphragmatic segment of esophagus preventing reflux [14]. With further EGJ degradation there is dilatation of the diaphragmatic hiatus, which diminishes its "pinchcock" action of crimping closed and angulating the esophagus with inspiration, abdominal straining, or coughing [8,17-19]. Hiatal dilatation also increases the compliance of the LES, leading to greater opening diameters such that gas venting events are often accompanied by gastric acid reflux and the overall volume of reflux increases [20]. Finally, with overt hiatus hernia, the diaphragmatic contribution to EGJ competence is completely disabled, now relying entirely on the LES itself [10]. Thus, although neither hiatus hernia nor a hypotensive LES alone results in severe EGJ incompetence, the two conditions interact with each other. This conclusion is consistent with the clinical observation that exercise, tight-fitting garments, and activities involving bending at the waist exacerbate heartburn, especially after having consumed meals that reduce LES pressure. (See "Pathophysiology of reflux esophagitis".)

- **Compromise of esophageal emptying** – Patients with type I hiatus hernia have prolongation in acid clearance especially while recumbent. The hiatus hernia compromises fluid emptying from the distal esophagus by "re-reflux" from the hernia compartment during swallowing (figure 6) [21,22]. Re-reflux occurs predominantly during inspiration and can be attributed to loss of the normal one-way valve function of the crural diaphragm. By pinching off the distal esophagus, the crural diaphragm prevents backward flow from the stomach during each inspiration when it would be favored by a positive abdominal-thoracic pressure gradient. This one-way valve function of the crural diaphragm is grossly impaired with large type I hernias because a gastric pouch persists above the diaphragm [21].

Type II, III, and IV: Paraesophageal hernias — While it is unclear if this is either a cause or effect, paraesophageal hernias are associated with abnormal laxity of the gastrosplenic and gastrocolic ligaments, which normally prevent displacement of the stomach. As the hernia enlarges, the greater curvature of the stomach rolls up into the thorax. Because the stomach is fixed at the EGJ, the herniated stomach tends to rotate around its longitudinal axis, resulting in an organoaxial volvulus (figure 7) [23]. Infrequently, rotation occurs around the transverse axis, resulting in a mesenteroaxial volvulus [23]. Over time, the entire stomach can eventually herniate, with the pylorus juxtaposed to the gastric cardia, forming an upside-down, intrathoracic stomach.

CLINICAL FEATURES

Clinical manifestations — Type I (sliding) hiatal hernias are often asymptomatic or associated with symptoms of gastroesophageal reflux disease (GERD), the most common of which are heartburn, regurgitation, and dysphagia. (See "Clinical manifestations and diagnosis of gastroesophageal reflux in adults", section on 'Clinical manifestations'.)

Complications are rare in patients with type I hiatal hernia and are usually related to reflux esophagitis (see "Complications of gastroesophageal reflux in adults"). However, large type I hernias can be associated with Cameron lesions, which appear as linear erosions at the level of the hiatus and are a cause of iron deficiency anemia [24].

Patients with type II, III, and IV (paraesophageal) hernias can be asymptomatic or have only vague, intermittent symptoms [11]. The most common symptoms are epigastric or substernal pain, postprandial fullness, nausea, and retching. GERD symptoms are less prevalent as compared with patients with a type I hernia.

Most complications of a paraesophageal hernia are due to mechanical problems caused by the hernia and include the following:

- Gastric volvulus can occur with large paraesophageal hernias, causing dysphagia, postprandial pain, ischemia, and (rarely) strangulation.
- Bleeding, although infrequent, occurs from gastric ulceration, gastritis, or erosions within the incarcerated hernia pouch.
- Dyspnea can result from limited lung expansion because of a large part of the stomach or other organs herniating through the hiatus.

Radiographic findings — In patients with paraesophageal hernias, an upright radiograph, computed tomography (CT) scan, or magnetic resonance imaging (MRI) of the chest may reveal a retrocardiac air-fluid level within a paraesophageal hernia or intrathoracic stomach (image 1 and image 5). In type IV paraesophageal hernia, other organs within the hernia sac can be identified on CT or MRI of the chest (image 4).

DIAGNOSIS

A type I (sliding) hiatus hernia is suspected in patients with symptoms of gastroesophageal reflux disease (GERD) including heartburn, regurgitation, and dysphagia. A type II, III and IV

(paraesophageal) hernia is suspected in patients with a history of surgical dissection of the hiatus (eg, antireflux procedures, esophagomyotomy, or partial gastrectomy) and epigastric or substernal pain or fullness, nausea, or vomiting. However, hiatus hernia is usually diagnosed incidentally on upper endoscopy, manometry, or imaging studies done for other reasons. (See 'Radiographic findings' above and "Approach to the evaluation of dysphagia in adults", section on 'Symptom-based differential diagnosis' and "Clinical manifestations and diagnosis of gastroesophageal reflux in adults", section on 'Differential diagnosis'.)

Paraesophageal hernias may be diagnosed on an upper endoscopy, but barium swallow is the most sensitive diagnostic test.

- Sliding hiatal hernias that are larger than 2 cm in axial span can be diagnosed by barium swallow, endoscopy, or esophageal manometry. In contrast, small sliding hiatus hernias can only be diagnosed with certainty during surgery [25].

  Upper endoscopy and barium swallow are unreliable for defining smaller sliding hiatus hernias as the esophagogastric junction (EGJ) is highly mobile and because of the lack of standardization as to when the size of hiatus hernia should be measured with respect to peristalsis and the extent of gastric distention. Only when a sliding hiatal hernia is >2 cm is its presence obvious because gastric folds are evident traversing the diaphragm both during swallow-induced esophageal shortening and at rest (image 6).

Barium swallow — Barium swallow can determine the anatomy and size of the hernia, orientation of the stomach, and location of the EGJ (image 2). A sliding hiatus hernia is characterized by a greater than 2-cm separation between the mucosal B ring at the site of the squamocolumnar junction and the diaphragmatic hiatus (figure 2). If a B ring is not evident on barium swallow, the demonstration of at least three rugal folds traversing the diaphragm is diagnostic of a sliding hiatus hernia (image 6).

Visualization of a portion of the gastric fundus herniating along the distal esophagus on barium swallow is diagnostic of a paraesophageal hernia (image 7).

Upper endoscopy — On upper endoscopy, the axial length of a sliding hiatus hernia is measured by the degree of separation between the squamocolumnar junction and the diaphragmatic impression from a retroflexed view after distending the stomach and even tugging along the lesser curve to elicit herniation (picture 1) [15].

In patients with a paraesophageal hernia, retroflexed view on upper endoscopy shows a portion of the stomach herniating upward through the diaphragm adjacent to the endoscope.

High-resolution manometry — On high-resolution manometry (HRM), a hiatus hernia is characterized by the spatial separation between the crural diaphragm (CD) and lower esophageal sphincter (LES) [12,25]. It also allows for prolonged observation that enables the identification of intermittent herniation (figure 8). Small sliding hiatus hernias with less than 2 cm separation between the LES and CD often reduce spontaneously during prolonged manometric recordings (see "High resolution manometry", section on 'Anatomic sphincters'). An analysis comparing the accuracy of HRM, endoscopy, and barium radiography to surgery in detecting and sizing hiatus hernia [26] concluded that HRM, using the LES-CD separation metric, outperformed the other modalities with a sensitivity of 94 percent, specificity of 92 percent, and kappa value of 0.85. In that analysis, HRM reached both optimal sensitivity and specificity for detecting hiatus hernia, with a threshold LES–CD separation of 1.2 cm. Furthermore, as the LES and CD become spatially separate, there is the added issue of whether the respiratory inversion point (RIP), the locus at which the inspiratory effect on intraluminal pressure transitions from augmentation (characteristic of the abdomen) to a reduction (characteristic of the chest), remains in its native position above the LES or not. Although the precise physiologic meaning of the RIP is uncertain and its localization sometimes challenging, there can be general agreement that: the RIP can never be below the diaphragm; when the CD is superimposed on the LES, the RIP localizes above the EGJ pressure complex, placing the LES physiologically within and beneath the diaphragmatic hiatus; and with spatial separation of the CD and LES, the RIP can localize either at or above the CD component, placing it either within the hernia or at the LES (figure 8) [27].

DIFFERENTIAL DIAGNOSIS

The differential diagnosis of hiatus hernia includes other etiologies of epigastric or substernal pain, dysphagia, heartburn or regurgitation, and refractory gastroesophageal reflux disease. This includes esophagitis, an esophageal motility disorder, functional dyspepsia, and coronary artery disease. While an evaluation to exclude these diagnoses is not required to diagnose a hiatus hernia, it may be necessary in patients with refractory symptoms and is discussed in detail, separately. (See "Clinical manifestations and diagnosis of gastroesophageal reflux in adults", section on 'Evaluation in selected patients'.)

MANAGEMENT

Sliding hiatus hernia — Surgical repair of an asymptomatic type I hiatal hernia is not indicated. Management of patients with a symptomatic sliding hiatus hernia consists of management of gastroesophageal reflux disease (GERD). Medical management of GERD and the role of surgery

in the management of GERD are discussed separately. (See "Medical management of gastroesophageal reflux disease in adults" and "Surgical treatment of gastroesophageal reflux in adults".)

Paraesophageal hernia — The optimal management of asymptomatic patients with paraesophageal hernias is controversial [28]. While a few experts recommend prophylactic surgical treatment even in the absence of symptoms, most experts advocate against it as the annual risk of developing acute symptoms requiring emergent surgery is less than 2 percent and the mortality rate from elective paraesophageal hernia repair is approximately 1.4 percent [29,30].

Surgical repair is indicated in patients with a symptomatic paraesophageal hernia [29]. Emergent repair is required in patients with a gastric volvulus, uncontrolled bleeding, obstruction, strangulation, perforation, and respiratory compromise secondary to a paraesophageal hernia [11,28,30-32]. The indications for surgical repair, preoperative evaluation, and the technical aspects of surgical repair of paraesophageal hernias are discussed in detail, separately. (See "Medical management of gastroesophageal reflux disease in adults", section on 'Initial management' and "Surgical management of paraesophageal hernia", section on 'Indications for surgical repair'.)

SOCIETY GUIDELINE LINKS

Links to society and government-sponsored guidelines from selected countries and regions around the world are provided separately. (See "Society guideline links: Hiatal hernia".)

INFORMATION FOR PATIENTS

UpToDate offers two types of patient education materials, "The Basics" and "Beyond the Basics." The Basics patient education pieces are written in plain language, at the 5th to 6th grade reading level, and they answer the four or five key questions a patient might have about a given condition. These articles are best for patients who want a general overview and who prefer short, easy-to-read materials. Beyond the Basics patient education pieces are longer, more sophisticated, and more detailed. These articles are written at the 10th to 12th grade reading level and are best for patients who want in-depth information and are comfortable with some medical jargon.

Here are the patient education articles that are relevant to this topic. We encourage you to print or e-mail these topics to your patients. (You can also locate patient education articles on a

variety of subjects by searching on "patient info" and the keyword(s) of interest.)

- Basics topics (see "Patient education: Hiatal hernia (The Basics)")

SUMMARY AND RECOMMENDATIONS

- **Definition** – Hiatus hernia refers to herniation of elements of the abdominal cavity through the esophageal hiatus of the diaphragm. (See 'Definition' above.)

- **Classification** – Hiatus hernias are broadly divided into sliding and paraesophageal hernias (figure 4 and image 2). A type I or sliding hiatus hernia is characterized by the displacement of the esophagogastric junction (EGJ) above the diaphragm. The stomach remains in its usual longitudinal alignment and the fundus remains below the EGJ. Type II, III, and IV hiatus hernias or paraesophageal hernias are characterized by an upward dislocation of the gastric fundus. Approximately 95 percent of all hiatus hernias are sliding and 5 percent are paraesophageal. (See 'Classification' above and 'Epidemiology' above.)

- **Etiology** – Although the etiology of most hiatus hernias is speculative, trauma, congenital malformation, and iatrogenic factors have been implicated in some patients with sliding hiatus hernias. Paraesophageal hernias are a recognized complication of surgical dissection of the hiatus. (See 'Etiology' above.)

- **Pathophysiology** – A sliding hiatus hernia results from progressive disruption of the EGJ that allows a portion of the gastric cardia to herniate upward (figure 9). In contrast, paraesophageal hernias are associated with abnormal laxity of the gastrosplenic and gastrocolic ligaments, which allows the greater curvature of the stomach to roll up into the thorax. (See 'Pathophysiology' above.)

- **Clinical features** – Most small sliding hiatus hernias are asymptomatic. Patients with large sliding hiatus hernias may have symptoms of gastroesophageal reflux disease (GERD). Many patients with paraesophageal hernias are either asymptomatic or have only vague, intermittent symptoms of epigastric or substernal pain or postprandial fullness, nausea, and retching. In patients with paraesophageal hernias, an upright radiograph, computed tomography (CT) scan, or magnetic resonance imaging (MRI) of the chest may reveal a retrocardiac air-fluid level within a paraesophageal hernia or intrathoracic stomach (image 1 and image 5 and image 4). (See 'Clinical features' above.)

- **Diagnosis** – Hiatus hernia is usually discovered incidentally on upper endoscopy, manometry, or imaging done for other reasons or during a work-up for GERD.

Paraesophageal hernias may be diagnosed on an upper endoscopy, but barium swallow is the most sensitive diagnostic test. Sliding hiatal hernias that are larger than 2 cm in axial span can be diagnosed by barium swallow, endoscopy, or esophageal manometry, but smaller sliding hernias are often only detected during surgery. (See 'Diagnosis' above.)

- **Management**

  - **Sliding hiatus hernia** – Repair of an asymptomatic sliding hiatus hernia is not indicated. Management of patients with a symptomatic sliding hiatus hernia consists of management of GERD. (See 'Management' above and "Medical management of gastroesophageal reflux disease in adults" and "Approach to refractory gastroesophageal reflux disease in adults" and "Surgical treatment of gastroesophageal reflux in adults".)

  - **Paraesophageal hernia** – Surgical repair for paraesophageal hernias is reserved for symptomatic patients and for management of complications (eg, gastric volvulus, bleeding, obstruction, strangulation, perforation, and respiratory compromise secondary to a paraesophageal hernia). (See 'Clinical manifestations' above and 'Management' above and "Surgical management of paraesophageal hernia", section on 'Indications for surgical repair'.)

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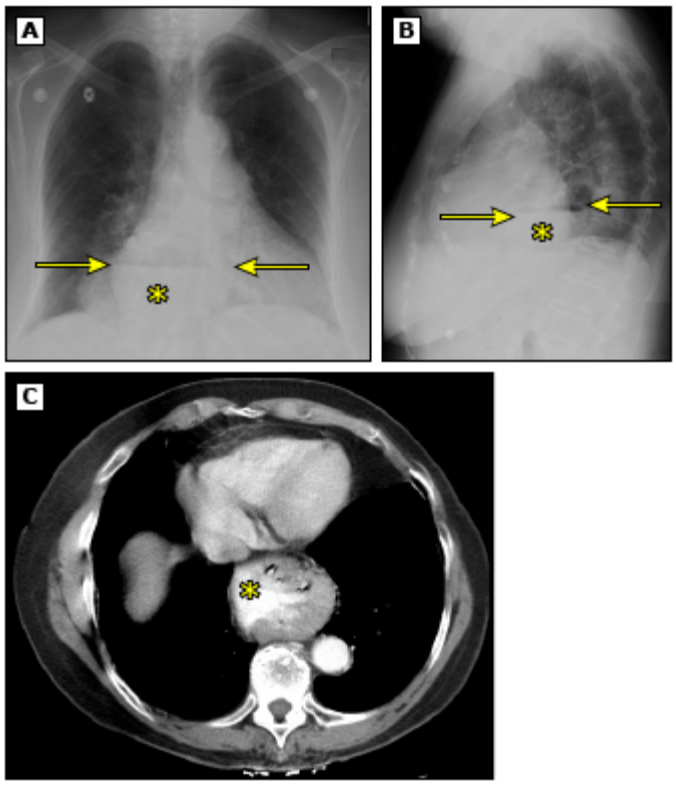
GRAPHICS

Incidental finding of a hiatus hernia on chest x-ray and CT scan

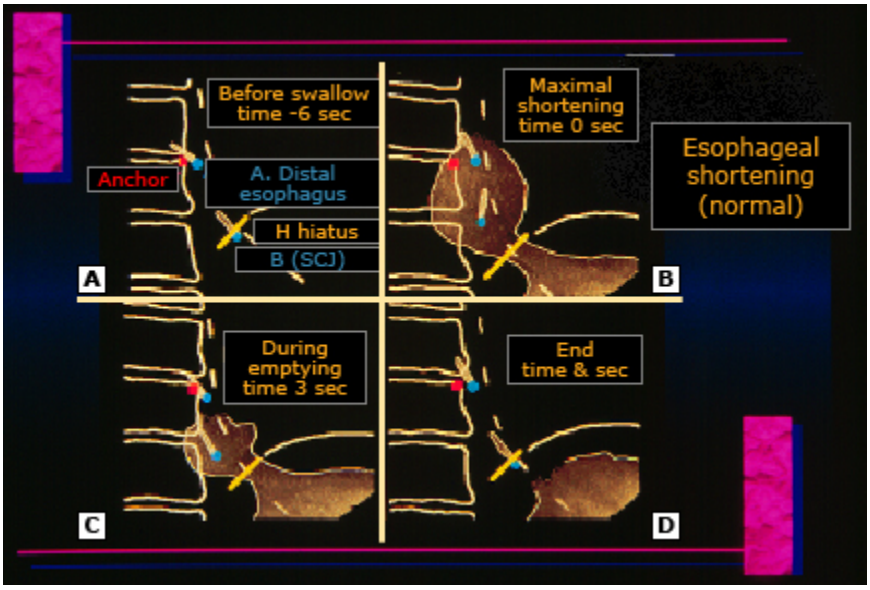


The A-P chest x-ray (A) shows a hiatus hernia (asterisk) with an air fluid level (arrows). A lateral chest x-ray (B) confirms a hiatus hernia (asterisk) and an air fluid level in the hernia (arrows). A CT scan in the axial plane (C) shows contrast in the hiatus hernia (asterisk).

A-P: anteroposterior; CT: computed tomography.

Graphic 90295 Version 2.0

Esophageal shortening during swallow



(A) Before swallow - Clip B marks the position of the squamocolumnar junction (SCJ), 35 mm distal to the anchor point on the vertebral body; clip A is affixed to the esophageal mucosa 31 mm proximally. Clip movements are referenced to point V on the vertebral column.

(B) At the time of maximal esophageal shortening during swallow, clip B is 20 mm distal to point V and the distance between clips A and B is reduced to 22 mm, indicative of 29 percent shortening.

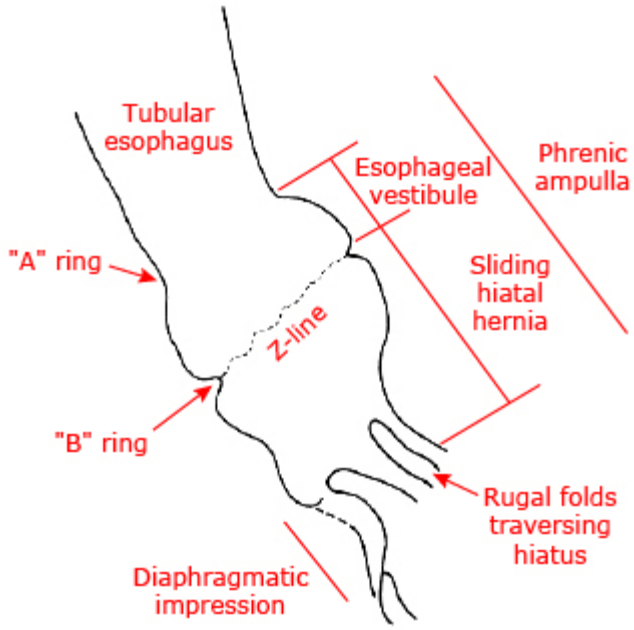
(C) As elongation proceeds, first both clips descend, after which clip B descends, stretching the A-B segment back to its initial length.

(D) After swallow recovery to normal.

With permission from: Kahrilas PJ, Wu S, Lin S, et al. Attenuation of esophageal shortening during peristalsis with hiatus hernia. Gastroenterology 1995; 109:1818.

Graphic 61193 Version 4.0

Anatomic features of sliding hiatus hernia

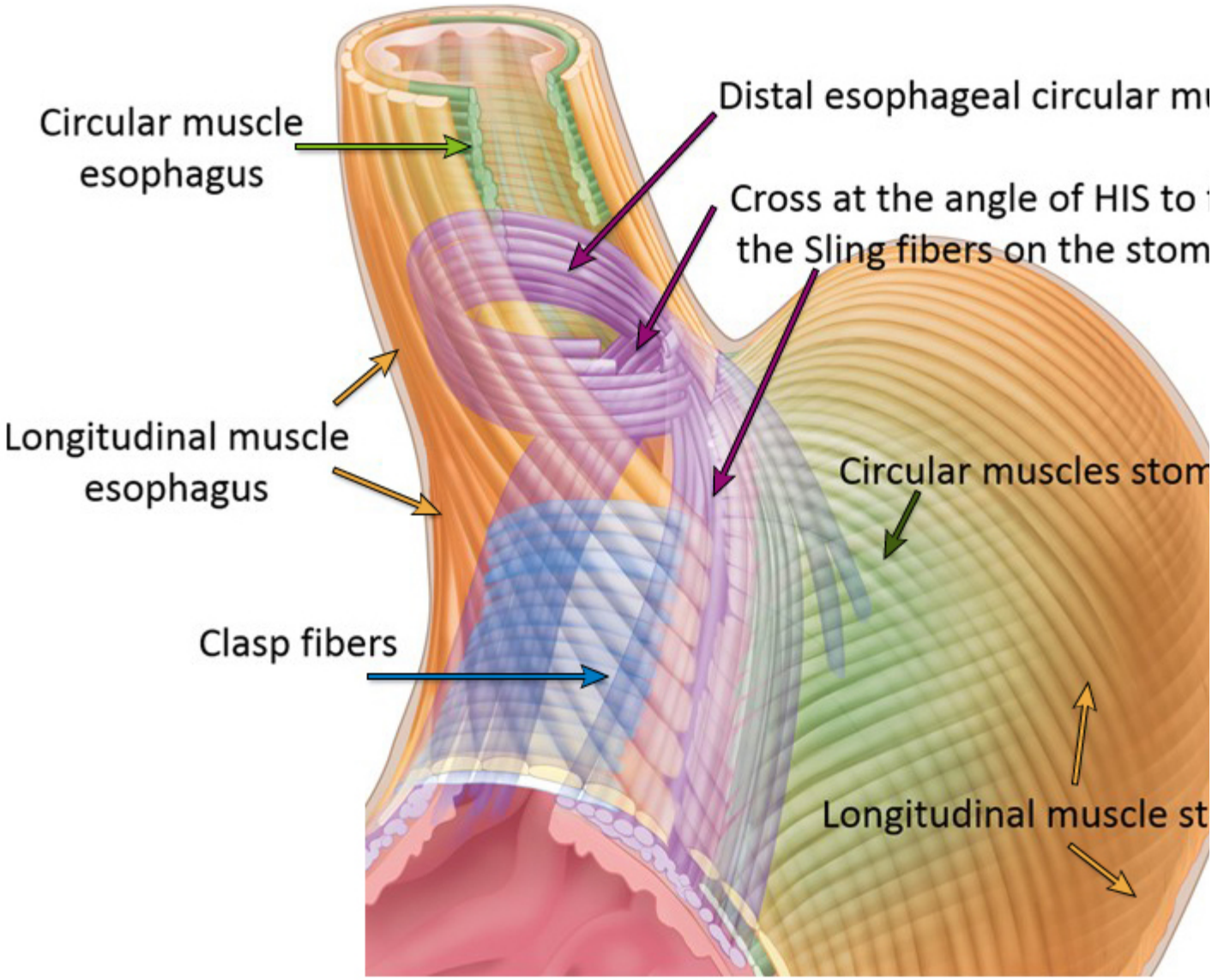


Representation of the anatomic features of a sliding hiatus hernia viewed radiographically during swallowing. The "A" ring is a muscular ring visible during swallowing which demarcates the superior margin of the lower esophageal sphincter. The "B" ring at the squamocolumnar junction is present in only about 15 percent of individuals; it permits accurate division of the phrenic ampulla into the esophageal vestibule (A ring to B ring) and the sliding hiatus hernia (B ring to the subdiaphragmatic stomach). Rugal folds traversing the hiatus support the conviction that a portion of the stomach is supradiaphragmatic.

Reproduced with permission from: Kahrilas PJ. Hiatus hernia causes reflux: Fact or fiction? Gullet 1993; 3(Suppl):21.

Graphic 72582 Version 4.0

Three-dimensional myoarchitecture of the LES



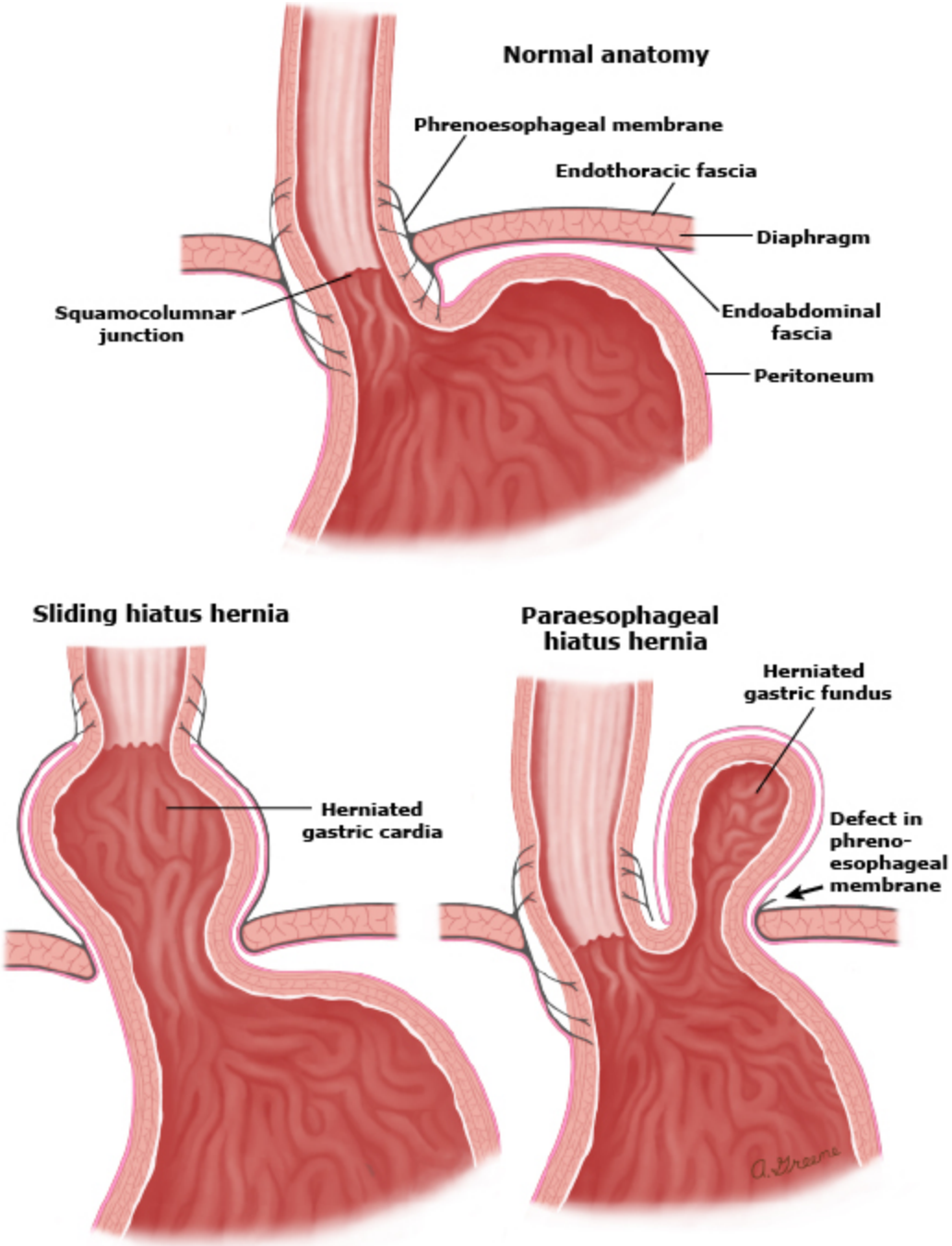
Three-dimensional myoarchitecture of the LES using optical sectioning microscopy and computer reconstru
bloc resection from young human cadaver.

LES: lower esophageal sphincter.

From: Zifan A, Kumar D, Cheng LK, Mittal RK. Three-dimensional myoarchitecture of the lower esophageal sphincter and esophageal h using optical sectioning microscopy. Sci Rep 2017; 7:13188. Copyright © 2017 The Authors. Available at: www.nature.com/articles/s41 13342-y (Accessed on January 18, 2023). Reproduced under the terms of the Creative Commons Attribution License 4.0.

Graphic 140575 Version 1.0

Sliding versus paraesophageal hiatus hernia



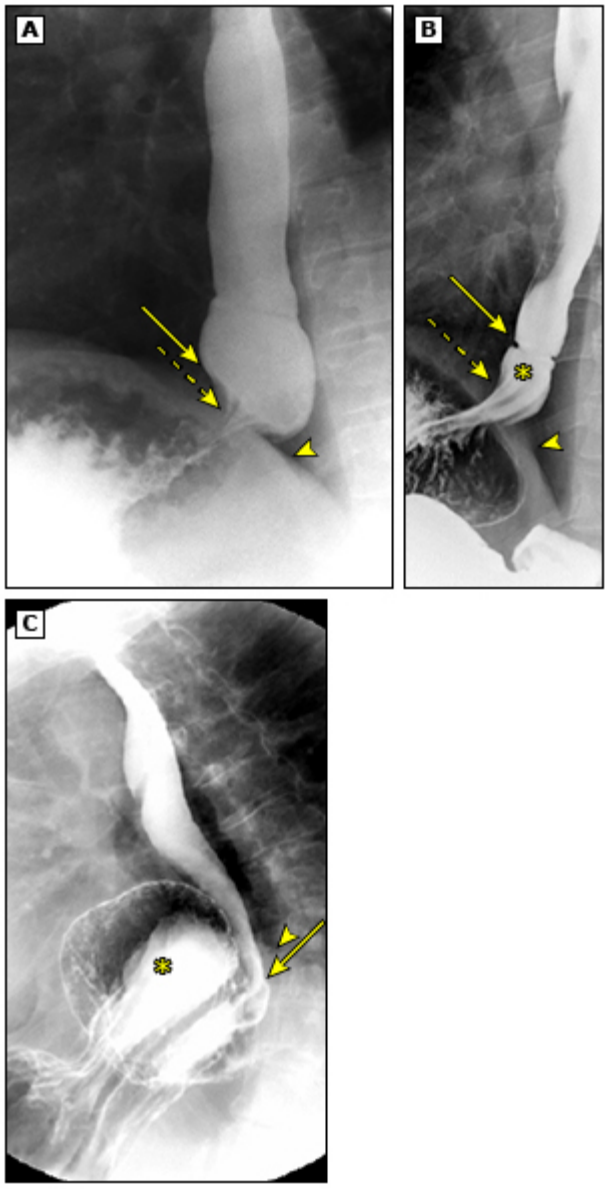
Distinction between a sliding hiatus hernia (type I) and paraesophageal hernia (type II). With type I hernia, the leading edge is the gastric cardia while with type II it is the gastric fundus. The squamocolumnar junction maintains its native position in the paraesophageal hernia while it is displaced upward with the sliding hernia.

SC: squamocolumnar.

Kahrilas PJ, Kim HC, Pandolfino JE. Approaches to the diagnosis and grading of hiatal hernia. Best Pract Res Clin Gastroenterol 2008; 22:601.

Graphic 62190 Version 5.0

Barium swallow in a patient with a hiatus hernia



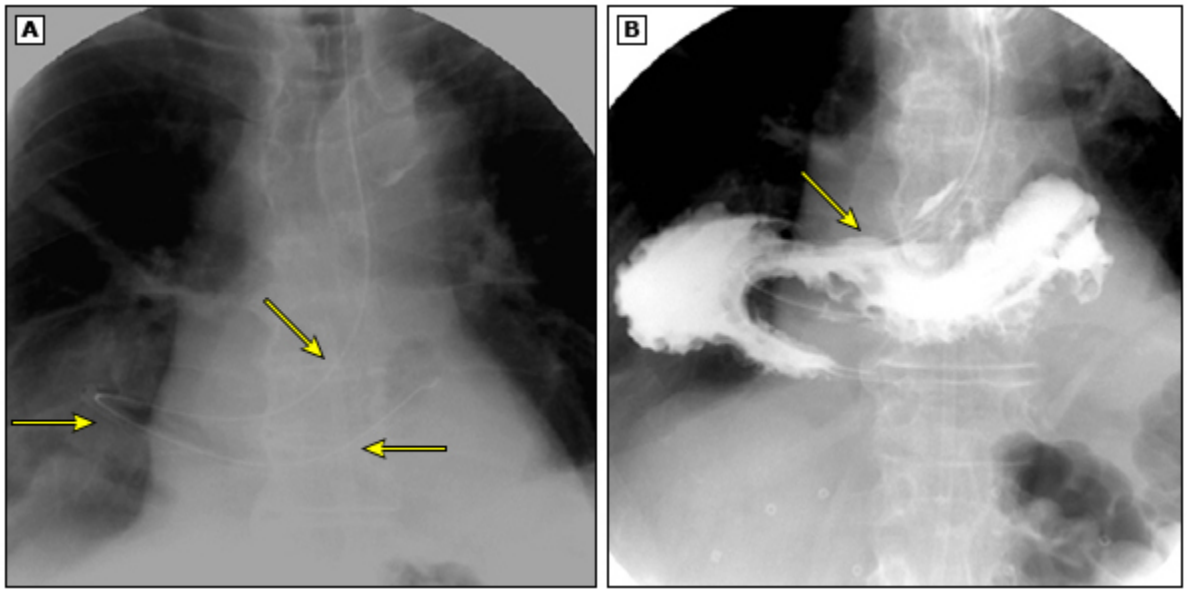
(A) Normal barium swallow showing the gastroesophageal junction (arrow) is at the level of the diaphragm (arrowhead) and the gastric folds (dashed arrow) are at the same level as the diaphragm.

(B) Barium swallow showing a sliding hiatus hernia (asterisk). The gastroesophageal junction (arrow) is above the diaphragm (arrowhead) and the gastric folds (dashed arrow) are above the diaphragm.

(C) Barium swallow showing a paraesophageal hernia (asterisk). The gastroesophageal junction (arrow) is below the diaphragm (arrowhead).

Graphic 90296 Version 2.0

Barium swallow in a patient with a type III paraesophageal hernia

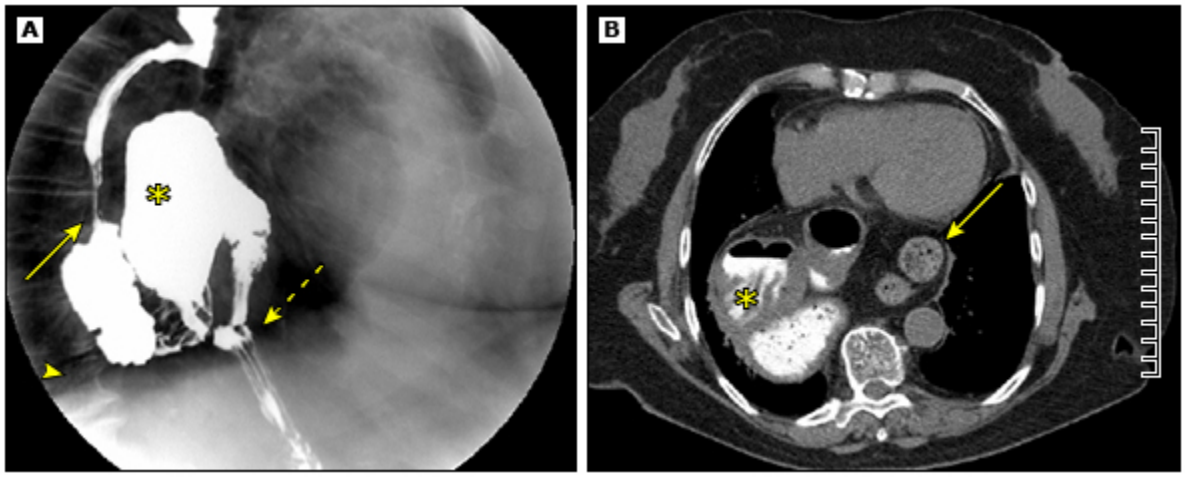


(A) A chest x-ray prior to contrast administration shows the nasogastric tube coiled in the chest (arrows).

(B) Following barium administration through the nasogastric tube, the gastroesophageal junction and the entire stomach are noted within the chest.

Graphic 90299 Version 2.0

Barium swallow and computed tomography (CT) scan in a patient with a type IV paraesophageal hiatus hernia

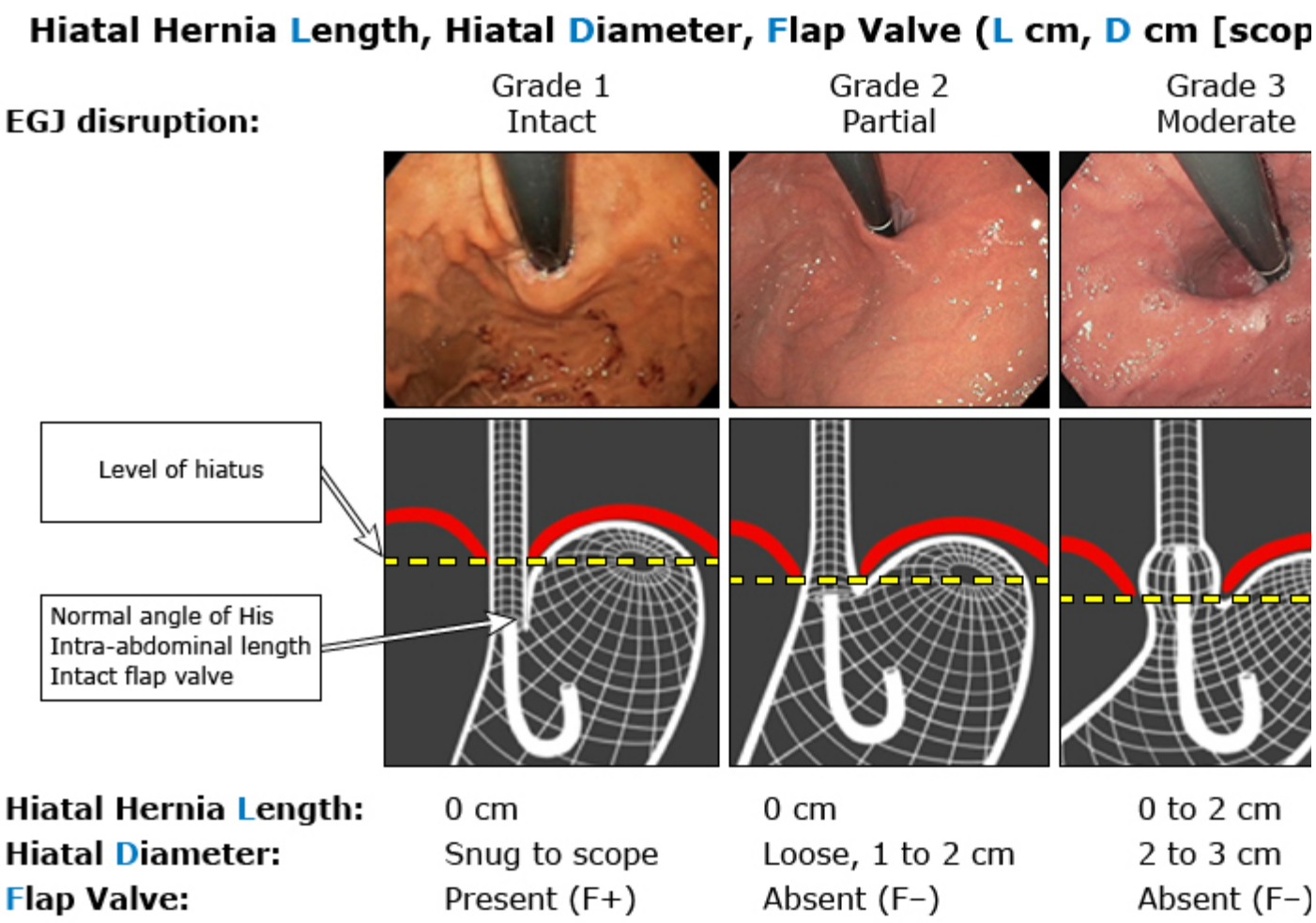


(A) A barium swallow showing the entire stomach within the chest (asterisk). The gastroesophageal junction (arrow) is above the diaphragm (arrowhead) and the first part of the duodenum (dashed arrow) is at the level of the diaphragm.

(B) A CT scan through the lower chest showing the herniated stomach (asterisk) and portions of the colon within the hernial sac in the chest (arrow).

Graphic 90300 Version 2.0

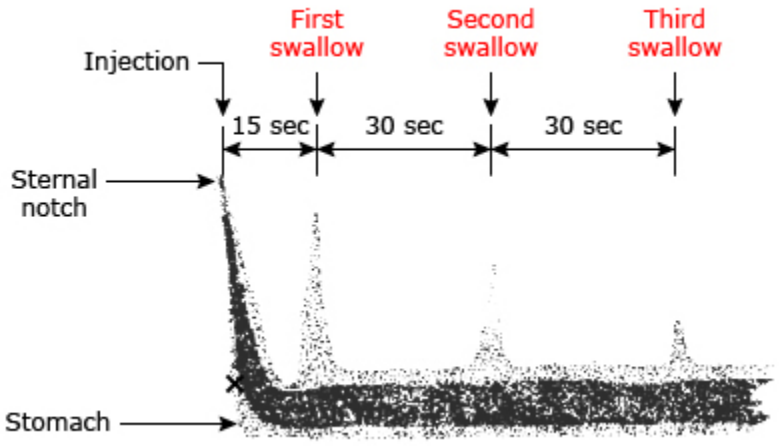
AFS endoscopic classification of the EGJ



Adapted from: Nguyen, N.T., et al. The American Foregut Society White Paper on the Endoscopic Classification of Esophagogastric Junc the American Foregut Society 2(4), pp.339-348. Copyright © 2022 by the Authors. Reprinted by permission of SAGE Publications, Inc.

Graphic 140578 Version 2.0

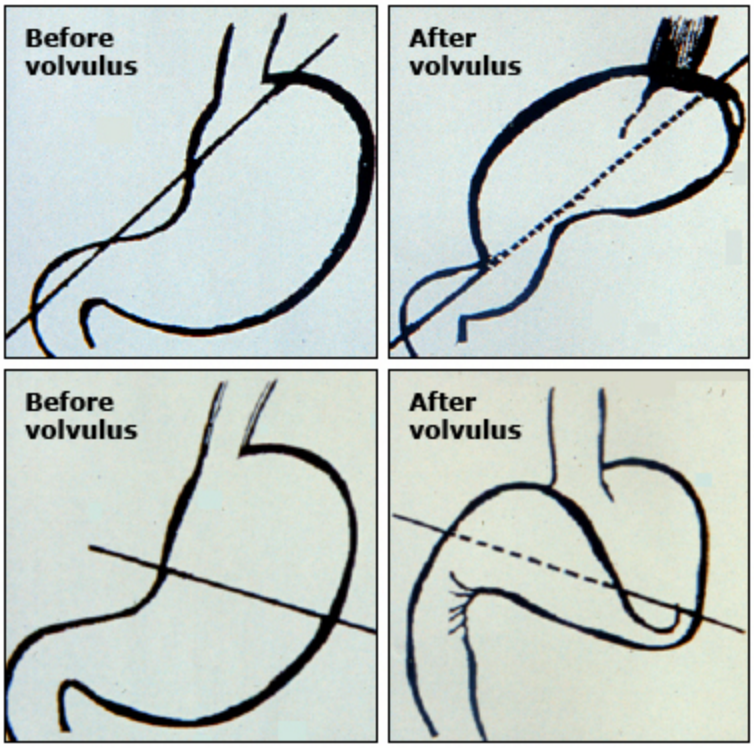
Rereflux with hiatus hernia



Depiction of a radionuclide acid clearance study in a subject with a hiatus hernia. Fifteen seconds after the injection of a 15 mL bolus of 0.1 N HCl labeled with 200 microcuries of 99mTc-sulfur colloid, subjects swallowed every 30 seconds. The vertical axis represents the region from the sternal notch to the stomach. The horizontal axis is the time scale. The radioactivity is represented by the black area and no radioactivity is represented by the absence of black color. Soon after injection, the radioactivity appears in the stomach. However, there is reflux of isotope into the esophagus followed by clearance of the isotope during each of the first three swallows.

Graphic 72024 Version 5.0

Volvulus in hiatus hernia

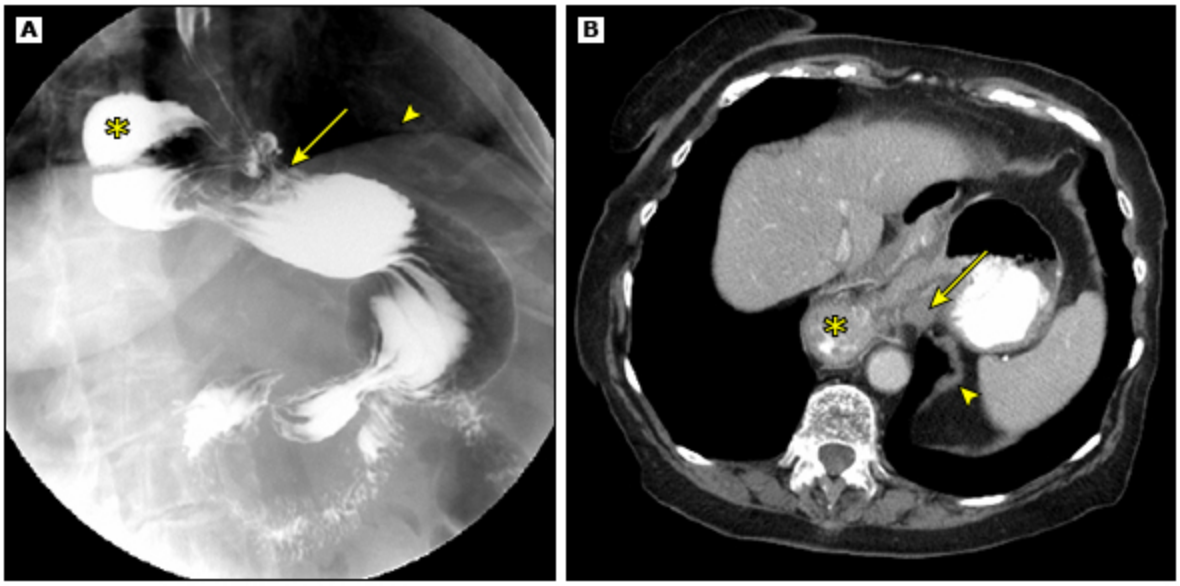


Paraesophageal hernias are associated with abnormal laxity of structures normally preventing displacement of the stomach, the gastrosplenic and gastrocolic ligaments. As the hernia enlarges, the greater curvature of the stomach rolls up into the thorax. Because the stomach is fixed at the gastroesophageal junction, the herniated stomach tends to rotate around its longitudinal axis, resulting in an organoaxial volvulus (top panels); infrequently, rotation occurs around the transverse axis resulting in a mesenteroaxial volvulus (bottom panels).

Adapted from: Peridikis G, Hinder RA. Paraesophageal hiatal hernia. In: Hernia, Nyhus LM, Condon RE (Eds), JB Lippincott, Philadelphia 1995. p.544.

Graphic 73205 Version 4.0

Barium swallow and computed tomography (CT) scan in a patient with a paraesophageal hernia

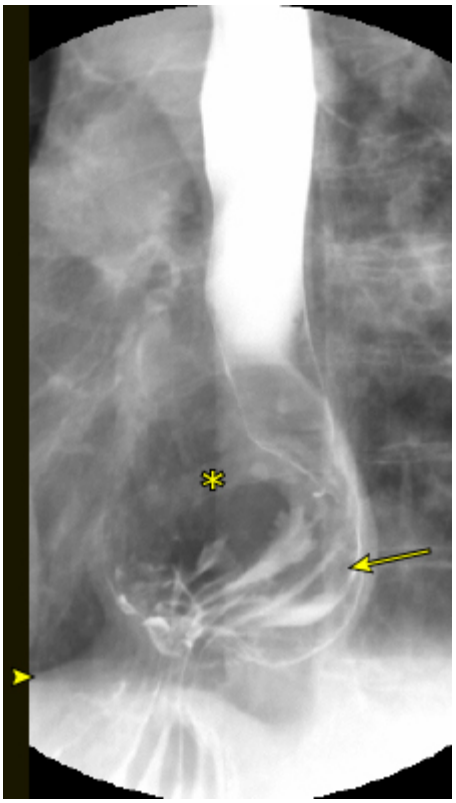


(A) A barium swallow showing a paraesophageal hernia (asterisk). The gastroesophageal junction (arrow) is at the level of the diaphragm (arrowhead).

(B) An axial CT scan through the lower chest showing the region of the gastroesophageal junction (arrow) at the level of the diaphragm (arrowhead) with a paraesophageal hernia (asterisk).

Graphic 90298 Version 2.0

Barium swallow in a patient with a sliding hiatus hernia



A barium swallow shows a moderate sized sliding hiatus hernia (asterisk) above the diaphragm (arrowhead), with well-defined gastric folds (arrow).

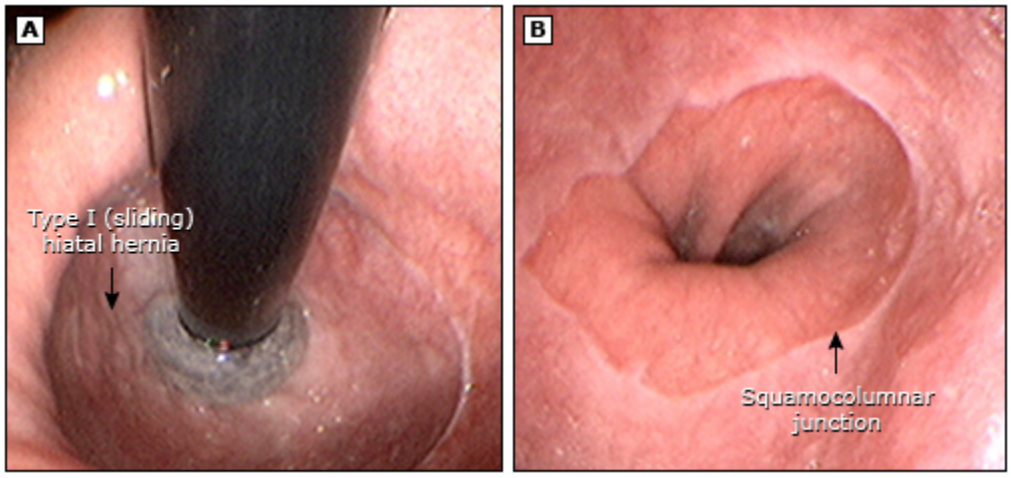
Graphic 90297 Version 2.0

Barium swallow of a large paraesophageal hernia

Barium swallow of a paraesophageal hernia. Note that as the herniated stomach enlarges, it inverts and twists causing a volvulus. In the extreme, this results in an upside-down stomach. The esophagus is not seen in this image, but if the gastroesophageal junction is at the level of the diaphragm, this would be a type II (paraesophageal) hernia. More commonly, it is above the diaphragm, which makes it a type III (paraesophageal) hernia.

Graphic 93824 Version 1.0

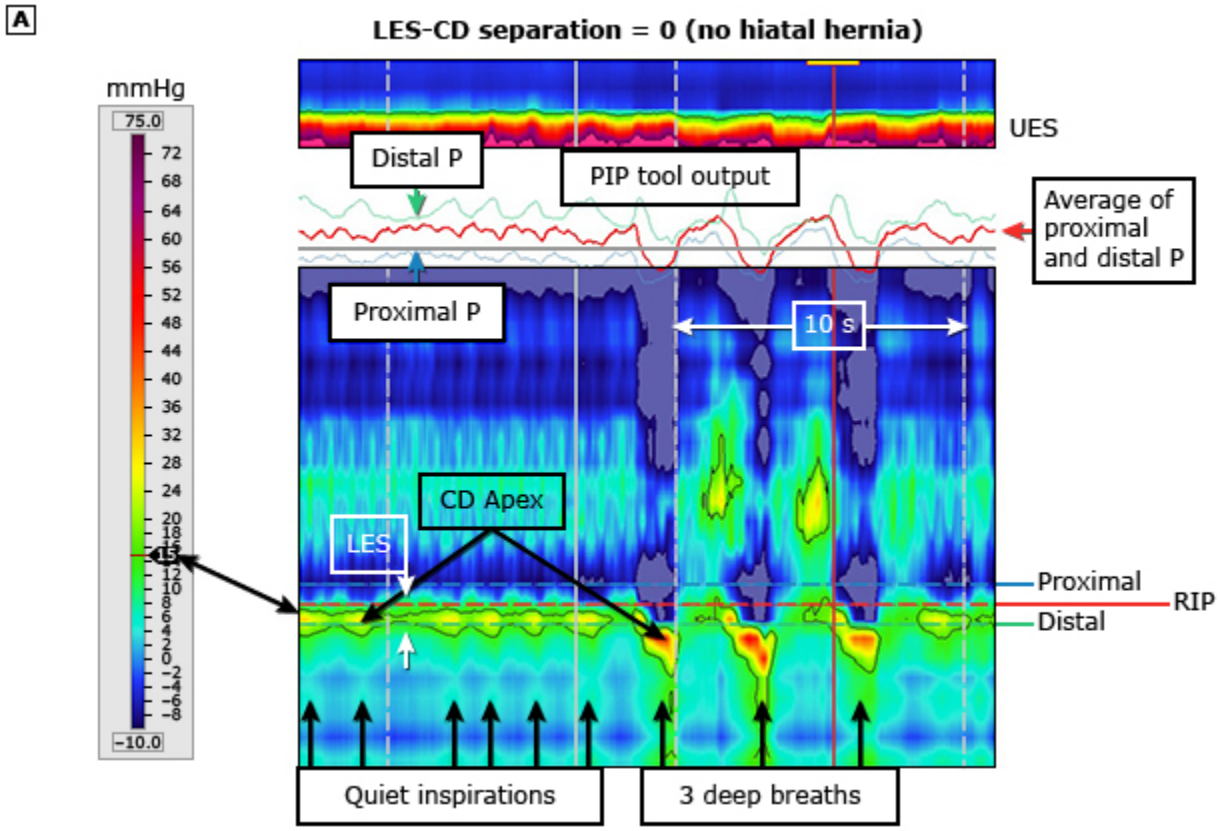
Endoscopic image of a type I sliding hiatus hernia

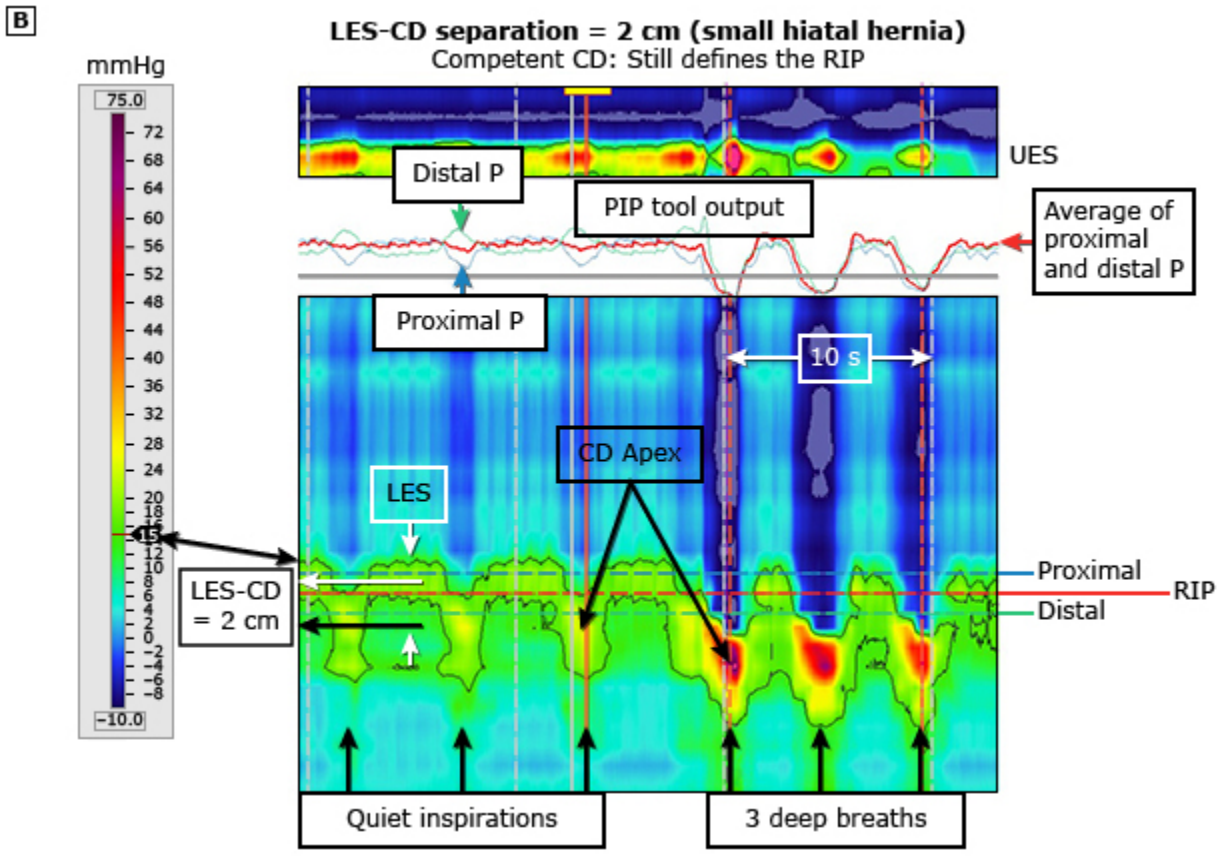


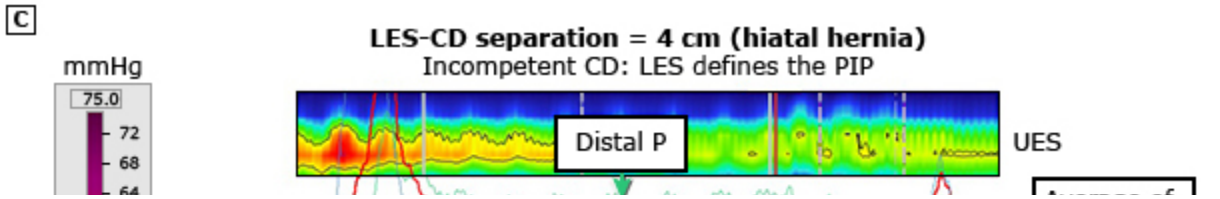
Retroflexed (A) and forward-looking (B) endoscopic views of a sliding (type I) hiatus hernia. The squamocolumnar junction (SCJ) marks the distal limit of the esophageal epithelium. Distal to the SCJ is the constriction of the diaphragmatic hiatus.

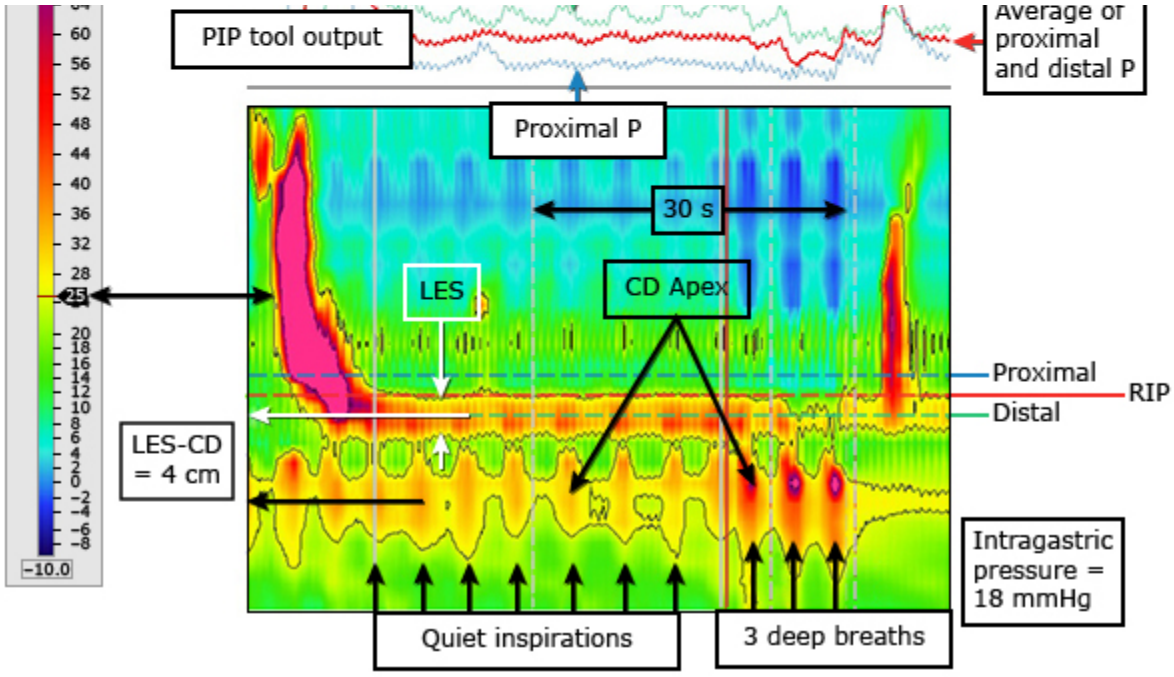
Graphic 93823 Version 1.0

High Resolution Manometry (HRM) recording of esophagogastric junction (EGJ) pressure


A
LES-CD separation = 0 (no hiatal hernia)
mmHg
75.0
72
68
64
60
56
52
48
44
40
36
32
28
24
20
18
15
12
10
8
6
4
2
0
-2
-4
-6
-8
-10.0
Distal P
PIP tool output
UES
Average of proximal and distal P
Proximal P
10 s
CD Apex
LES
Proximal
RIP
Distal
Quiet inspirations
3 deep breaths


B
LES-CD separation = 2 cm (small hiatal hernia)
Competent CD: Still defines the RIP
mmHg
75.0
72
68
64
60
56
52
48
44
40
36
32
28
24
20
18
15
12
10
8
6
4
2
0
-2
-4
-6
-8
-10.0
Distal P
PIP tool output
UES
Average of proximal and distal P
Proximal P
10 s
CD Apex
LES
LES-CD = 2 cm
Proximal
RIP
Distal
Quiet inspirations
3 deep breaths


C
LES-CD separation = 4 cm (hiatal hernia)
Incompetent CD: LES defines the PIP
mmHg
75.0
72
68
64
Distal P
UES



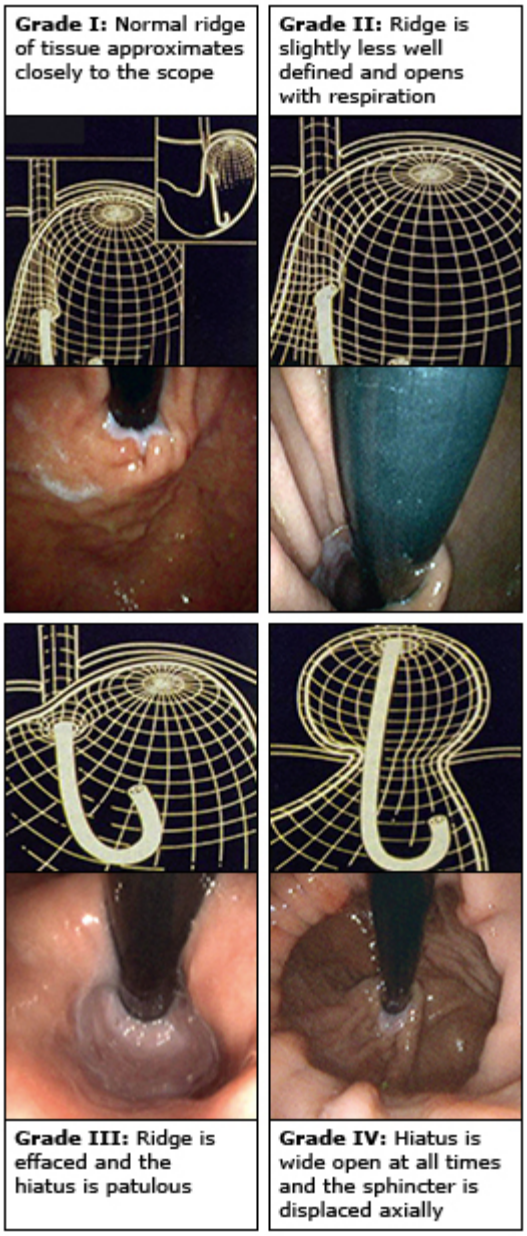
Panel A: High resolution manometry (HRM) recording of esophagogastric junction (EGJ) pressure in an individual without a hiatal hernia as evident by the crural diaphragm (CD) being completely superimposed on the lower esophageal sphincter (LES) pressure signature, ie, the LES-CD separation is 0. Both during quiet respiration and deep breaths, the LES is only evident between inspirations when the CD signal is minimal. In this example, the pressure inversion point (PIP) tool has been positioned to optimally isolate the respiratory inversion point (RIP) as evident by the PIP tool output shown as an insert. Barely visible on the pressure topography are a horizontal blue dashed line and green dashed line indicating the locations of the proximal and distal pressure (P) recordings shown in the PIP tool output. The red line in the PIP tool output box is the computed average of those signals. In using the tool, the area of interrogation is scrolled up and down to find the location at which the red line in the PIP tool output box is most nearly flat, indicative of the site at which the respiratory increases in pressure are offset by the respiratory decreases in pressure seen on the blue line. The area of interest is during quiet respiration and the RIP is seen to localize toward the upper margin of the CD signal. This positions the majority of the LES signal within the hiatus, being pulled downward during the three deep breaths.

Panel B: HRM recording of EGJ pressure in an individual with a small hiatal hernia as evident by the CD being only partially superimposed on the LES pressure signature, ie, the LES-CD separation is 2 cm. Formatting of the figure is identical to that of Panel A, with the dominant EGJ pressure profile highlighted by the black line (the 15 mmHg isobaric contour) and the PIP tool optimally positioned to isolate the RIP. Note how the LES-CD separation is measured. The center of the LES and CD high pressure zones (white and black horizontal arrows, respectively) are isolated with the help of the isobaric contour tool (set at 15 mmHg in this example), and the separation between the two rounded off to the nearest cm. In this example, the RIP continues to localize toward the upper margin of the CD signal, implying that the CD still exerts sufficient sphincteric effect such that it closes the lumen isolating the stomach below from the hernia and LES above. This is particularly evident during the three deep breaths where the strongly negative intrathoracic pressure (deep blue) is seen to abut directly on the CD-apex signal.

Panel C: HRM recording of EGJ pressure in an individual with a moderate-sized hiatal hernia as evident by the CD being isolated from the LES pressure signature, ie, the LES-CD separation is 4 cm. Formatting of the figure is identical to that of Panels A and B, with the dominant EGJ pressure profile highlighted by the black line (the 25 mmHg isobaric contour in this case) and the PIP tool optimally positioned to isolate the RIP. However, in this example, the RIP no longer localizes the CD signal, instead localizing at the proximal margin of the LES. Even without the aid of the PIP tool, that is evident by the inspiratory bursts of red on the LES recording. Consequently, the CD no longer functions as a competent extrinsic sphincter, and the entire hiatal hernia up to the lower margin of the LES is subject to intra-gastric pressure throughout the respiratory cycle.

Graphic 129815 Version 1.0

Progressive anatomic disruption of the gastroesophageal junction



Endoscopic appearance and corresponding three-dimensional representation of the progressive anatomic disruption of the gastroesophageal junction as occurs with development of a type I hiatus hernia. In the grade I configuration, a ridge of muscular tissue is closely approximated to the shaft of the retroflexed endoscope. With a grade II configuration the ridge of tissue is slightly less well defined and there has been slight orad displacement of the squamocolumnar junction along with widening of the angle of His. In the grade III appearance the ridge of tissue at the gastric entryway is barely present and there is often incomplete luminal closure around the endoscope. Note, however, that this is not a hiatal hernia because the squamocolumnar junction is not

displaced axially in the endoscopic photograph. With grade IV deformity, no muscular ridge is present at the gastric entry. The gastroesophageal area stays open all the time, and squamous epithelium of the distal oesophagus can be seen from the retroflexed endoscopic view. A hiatus hernia is always present with grade IV deformity.

Graphic 85907 Version 1.0

Contributor Disclosures

Peter J Kahrilas, MD Patent Holder: Medtronic [FLIP panometry methods and technology]. Consultant/Advisory Boards: Ironwood [Irritable bowel]; Johnson & Johnson [Anti-reflux surgery]; Reckitt [Reflux disease]. Speaker's Bureau: Phathom [Reflux disease, H. pylori]. All of the relevant financial relationships listed have been mitigated. **Nicholas J Talley, MD, PhD** Patent Holder: Australian Provisional Patent [Diagnostic marker for functional gastrointestinal disorders]; Biomarkers of irritable bowel syndrome [Irritable bowel syndrome]; Mayo Clinic [Dysphagia questionnaire]; Mayo Clinic [Bowel Disease questionnaire]; Nepean Dyspepsia Index [Dyspepsia]; Nestec [Irritable bowel syndrome]; Singapore Provisional Patent [BDNF Tissue Repair Pathway]. Grant/Research/Clinical Trial Support: Alimetry [Gastric mapping device research collaboration]; Allakos [Gastric eosinophilic disease]; AstraZeneca [Eosinophilic gastritis, eosinophilic gastroenteritis]; Intrinsic Medicine [Bowel syndrome with constipation]; NHMRC Centre for Research Excellence in Digestive Health [NHMRC Investigator grant]. Consultant/Advisory Boards: Adelphi Values [Functional dyspepsia]; Allakos [Gastric eosinophilic disease, AK002]; AstraZeneca [Eosinophilic gastritis, eosinophilic gastroenteritis]; AusEE [Eosinophilic gut diseases]; Bayer [Inflammatory bowel syndrome]; BluMaiden [Microbiome Ad Board]; Comvita Mānuka Honey [Digestive health]; Dr Falk Pharma [Eosinophilia]; GlaxoSmithKline Australia [Educational speaker eosinophilic gut disease]; Glutagen [Celiac disease]; International Foundation for Functional Gastrointestinal Disorders [Advisory board, functional GI disorders]; Intrinsic Medicine [Human milk oligosaccharide]; IsoThrive [Esophageal microbiome]; Planet Innovation [Gas capsule, inflammatory bowel syndrome]; Progenity Inc [Intestinal capsule]; Rose Pharma [IBS]; Viscera Labs [Inflammatory bowel syndrome, diarrhea]. Other Financial Interest: Elsevier textbook royalties [Medical education]. All of the relevant financial relationships listed have been mitigated. **Shilpa Grover, MD, MPH, AGAF** No relevant financial relationship(s) with ineligible companies to disclose.

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