Effects of Large Hiatal Hernias on Esophageal Peristalsis

Sabine Roman, MD, PhD; Peter J. Kahrilas, MD; Leila Kia, MD; Daniel Luger, BA; Nathaniel Soper, MD; John E. Pandolfino, MD

Hypothesis: Anatomic changes induced by large hiatal hernia may alter esophageal pressure topography measurements made during high-resolution manometry.

Design: Retrospective study.

Setting: Single-institution tertiary hospital.

Patients: Ninety patients with large (>5 cm) hiatal hernias on endoscopy were compared with a control group of 46 patients without hernia selected from the same database of 2000 consecutive clinical high-resolution manometry studies.

Intervention: High-resolution manometry with at least 7 evaluable swallows for analysis.

Main Outcomes Measures: Esophageal pressure topography was analyzed for lower esophageal sphincter pressure, distal contractile integral, contraction amplitude, contractile front velocity, and distal latency time. Esophageal length was measured on esophageal pressure topography from the distal border of the upper esophageal sphincter to the proximal border of the lower esophageal sphincter. Esophageal pressure topography diagnosis was based on the Chicago Classification.

Results: The manometry catheter was coiled in the hernia and did not traverse the diaphragm in 44 patients (49%) with large hernia. Patients with large hernias had lower average lower esophageal sphincter pressures, a lower distal contractile integral, slower contractile front velocity, and shorter distal latency time than patients without hernia. They also exhibited a shorter mean esophageal length. However, the distribution of peristaltic abnormalities was not different in patients with and without large hernia.

Conclusions: Patients with large hernias had an alteration of esophageal pressure topography measurements and a shortened esophagus. However, the distribution of peristaltic disorders was unaffected by the presence of hernia.

Arch Surg. 2012;147(4):352-357

HIATUS HERNIA IS A CONDITION in which elements of the abdominal cavity herniate through the esophageal hiatus into the mediastinum. Anatomic disruption of the esophagogastric junction (EGJ), phrenoesophageal ligament, and crural diaphragm (CD) plays an important role in the genesis of hiatus hernia.[1] Displacement of the lower esophageal sphincter (LES) above the CD creates a pouch of stomach between the 2 sphincters and this corresponds to a sliding hernia (type 1), which is the most common type of hernia.[2] Although the defining features of hiatus hernia pertain to the EGJ, there are also obligatory changes in the esophageal body associated with the axial displacement: the esophagus shortens and/or develops a tortuous configuration.

See Invited Critique at end of article

Evaluation of esophageal motility may be of interest in the context of hiatal hernia for many reasons. Esophageal manometry is required when surgery is considered in patients with gastroesophageal reflux disease to rule out achalasia and evaluate peristalsis.[3] It might also be useful in cases of dysphagia where there is a coexistent hiatus hernia to detect associated motility EGJ outflow obstruction at the level of the CD prior to surgical repair.[4] Because large hiatal hernias modify EGJ and esophageal body anatomy, esophageal pressure topography (EPT) measurements may be altered by these anatomic changes. Consequently, esophageal

Author Affiliations: Departments of Medicine (Drs Roman, Kahrilas, Kia, and Pandolfino and Mr Luger) and Surgery (Dr Soper), Feinberg School of Medicine, Northwestern University, Chicago, Illinois; and Department of Digestive Physiology, Hospices Civils de Lyon and Claude Bernard University Lyon I, Lyon, France (Dr Roman).

motility disorders may occur more frequently in patients with large hiatal hernia than in patients with normal EGJ anatomy.

Our aims in this analysis were to compare EPT measures of esophageal motility in patients with large hiatal hernia with those of a matched set of patients without hernia and to determine whether esophageal peristalsis was systematically altered by the presence of a large sliding hiatal hernia.

METHODS

SUBJECTS

A series of 2000 clinical EPT studies performed from January 2007 to May 2010 done using a consistent technique (ManoScan; Given Imaging) were systematically reviewed. Patients presented with diverse conditions consistent with an esophageal referral practice. The study protocol was approved by the Northwestern University institutional review board and informed consent was obtained from each subject.

After exclusion of patients with previous foregut surgery, achalasia, absent peristalsis, or less than 7 swallows suitable for analysis, we extracted patients with large (>5 cm) hiatal hernia identified during endoscopy. Esophageal pressure topography studies were included even if the manometry catheter did not enter into the subdiaphragmatic stomach through the CD. Within the same database, a control group of patients without hernia on endoscopy was selected and matched for sex, age, and symptoms (dysphagia and reflux) with the subset of patients with hernia in whom the manometry catheter did enter the subdiaphragmatic stomach.

STUDY PROTOCOL

High-resolution manometry (HRM) studies were done in a supine position after at least a 6-hour fast. The HRM catheter was a 4.2-mm outer diameter, solid-state assembly with 36 circumferential sensors at 1-cm intervals (Given Imaging). Transducers were calibrated at 0 and 300 mm Hg using externally applied pressure. The manometry assembly was placed transnasally and positioned to record from the hypopharynx to the stomach with about 3 intragastric sensors. The assembly was fixed in place by taping it to the nose. The study protocol included at least a 30-second baseline recording and ten 5-mL swallows.

EPT ANALYSIS

The EPT data were analyzed using ManoView analysis software (Given Imaging). End inspiratory and expiratory EGJ pressures were measured in the absence of swallowing at the level of the LES (or EGJ when the LES and CD were not distinguishable). Pressures were referenced to intra-abdominal and atmospheric pressures. Lower esophageal sphincter or EGJ relaxation was evaluated using the integrated relaxation pressure (IRP).[5] Nadir LES/EGJ pressure and percentage of relaxation were referenced to atmospheric pressure. The IRP was referenced to intra-abdominal pressure or intrahernia pressures in patients with large hiatal hernia. Percentage of LES/EGJ relaxation was calculated as

([LES/EGJ End Expiratory Pressure Before Swallowing] − [Nadir LES/EGJ Pressure During Swallowing]/LES/EGJ End Expiratory Pressure Before Swallowing).

For patients with large hiatal hernias and a catheter into the subdiaphragmatic stomach, EGJ morphology was classified as type IIIa when the LES-CD separation was greater than 2 cm at inspiration and the respiratory inversion point was proximal to the CD and as type IIIb when the LES-CD separation was greater than 2 cm and the respiratory inversion point was close to the LES.[6] Esophageal peristalsis was assessed using the following metrics: distal contractile integral,[7] maximal and mean amplitude distal to the transition zone, contractile front velocity,[8] and distal latency time (DL) between the onset of relaxation at the upper esophageal sphincter and the contractile deceleration point.[9] Esophageal peristalsis was then characterized according to the Chicago Classification[10] modified for weak peristalsis[11] and premature contractions.[12] A premature contraction was defined as a contraction with a DL less than 4.5 seconds, and a diagnosis of premature contractions required at least 2 swallows with a DL less than 4.5 seconds. Finally, esophageal length was measured on EPT from the distal border of the upper esophageal sphincter to the proximal border of the LES or EGJ (when the LES and CD were not discernible) at a 20–mm Hg isobaric contour.

CLINICAL DATA

Patients' medical records were reviewed to collect demographic data and the main symptom at the time of the HRM study. The assessment of a paraesophageal component to hiatus hernia was based on the endoscopy report or results of a barium swallow if available. For the patients who had surgery after the HRM, operative reports were also reviewed.

STATISTICAL ANALYSES

The EPT characteristics were expressed as median (5th-95th percentiles). Groups were then compared using the χ^2 test for categorical data and the Mann-Whitney or Kruskal-Wallis test for continuous data.

RESULTS

PATIENT CHARACTERISTICS

We identified 90 patients (26 men; mean age, 66 years; range, 42-86 years) with large hiatal hernia. The manometry catheter passed through the LES in all patients but not through the CD in 44 patients (49% of patients with large hiatal hernia). Thus, intra-abdominal pressure was not recorded in these 44 patients. Endoscopic catheter placement was attempted in 11 cases but was successful in only 4 patients. The control group included 46 patients and was matched to the group of 46 patients with large hiatal hernia and intra-abdominal pressure recorded. Patient characteristics are summarized in **Table 1**.

EGJ PRESSURES AND MORPHOLOGY

The EGJ pressure characteristics are presented in **Table 2**. End inspiratory and expiratory EGJ pressures were significantly lower in patients with large hiatal hernia and abdominal pressure recorded compared with patients without hernia and patients with hernia without intra-abdominal pressure recorded. The EGJ relaxation pressure was lower in patients with large hiatal hernias and abdominal pressure recorded (**Table 3**). Five subjects with large hiatal hernias presented with a mean IRP more than 15 mm Hg (1 in the group with abdominal pressure recorded and 4

Table 1. Patient Characteristics

	Large Hiatal Hernias: Intra-abdominal Pressure Not Recorded (n = 44)	Large Hiatal Hernias: Intra-abdominal Pressure Recorded (n = 46)	Controls (n = 46)
Sex, No.			
M	9	17	20
F	35[a]	29	26
Age, y, mean (range)	71 (45-86)[a]	62 (42-85)[b]	61 (37-83)
Weight, kg, mean (range)	81 (49-115)	85 (50-125)	80 (46-132)
Height, m, mean (range)	1.65 (1.45-1.85)	1.68 (1.50-1.93)	1.69 (1.52-1.83)
BMI, mean (range)	29.4 (19.1-43.2)	30.2 (19.2-44.1)[a]	27.8 (17.9-44.3)
Main symptom, No. (%)			
Dysphagia	14 (32)	11 (24)	14 (30)
Reflux	17 (38)	31 (67)[b]	31 (67)[b]
Chest pain	3 (7)	0	0
Other	10 (23)	4 (9)	1 (2)[b]

Abbreviation: BMI, body mass index (calculated as weight in kilograms divided by height in meters squared).

[a] $P < .05$ vs controls.

[b] $P < .05$ vs large hiatal hernia intra-abdominal pressure not recorded.

in the group with abdominal pressure not recorded). Outcome data were available in only 3 subjects with elevated IRP: 2 had a surgical hiatal hernia repair and dysphagia resolved after surgery and 1 patient who denied surgery still had dysphagia after 1 year.

In patients with large hernias and abdominal pressure recorded, no LES-CD separation was observed in 3 patients with paraesophageal hernia. The EGJ was classified as IIIa (respiratory inversion point just above the CD) in 33 patients (75%) and IIIb (respiratory inversion point close to the LES) in 10 patients (23%).

ESOPHAGEAL PERISTALSIS

The distal contractile integral was significantly smaller in patients with large hernia than in patients without hernia (820 mm Hg-s-cm [range, 153-2613 mm Hg-s-cm] in patients with intra-abdominal pressure not recorded vs 933 mm Hg-s-cm [range, 152-3543 mm Hg-s-cm] in patients with large hiatal hernias and abdominal pressure recorded vs 1459 mm Hg-s-cm [range, 326-5729 mm Hg-s-cm] in patients without hernia; $P < .05$) while the mean and maximal peristaltic amplitudes were not different among the groups (100 mm Hg [range, 47-225 mm Hg] vs 99 mm Hg [range, 54-230 mm Hg] vs 112 mm Hg [range, 55-255 mm Hg] for the maximal amplitude and 26 mm Hg [range, 18-53 mm Hg] vs 27 mm Hg [range, 16-47 mm Hg] vs 26 mm Hg [range, 13-56 mm Hg] for the mean amplitude). Since contraction segment length is a factor of distal contractile integral calculation and length might be systematically reduced in the patients with hernia, we also measured esophageal length. As evident in **Figure 1**, esophageal length was significantly shorter in patients with vs without large hiatal hernia. Even though contractile front velocity was greater (3.1 cm/s [range, 1.9-7.9 cm/s] in patients with intra-abdominal pressure not recorded vs 3.8 cm/s [range, 2.0-18.1 cm/s] in patients with large hiatal hernias and abdominal pressure recorded vs 4.5 cm/s [range, 2.7-11.4 cm/s] in patients without hernia; $P < .05$) and DL, shorter in patients with large hiatal hernia compared with patients without hernia (6.3 seconds [range, 4.5-8.4 seconds] vs 6.6 seconds [range, 5.2-8.8 seconds] vs 7.1 seconds [range, 5.1-9.2 seconds]; $P < .05$), the number of patients who would be classified as having rapid or premature contractions was not different among the groups (5 patients with large hernias had at least 2 swallows with a contractile front velocity >9 cm/s vs 2 without hernia; 3 patients with large hernias had at least 2 swallows with a DL <4.5 seconds vs 1 without hernia). Normal and weak peristalsis were the most frequent contractile patterns observed in all 3 groups (**Table 4**). No significant difference was observed in the distribution of the contractile pattern among groups ($P = .25$). However, 3 patients with large hiatal hernia without abdominal pressure recordings had at least 2 swallows with a reduced DL and consequently would fulfill criteria for spasm based on the presence of premature contractions. However, this may be an artifact from the reduced esophageal length or a loss of distal anchoring (**Figure 2**). The first patient presented with propagating peristalsis and a borderline DL (Figure 2A). The second and third patients had a significantly reduced DL with short esophagi, and although they would fulfill criteria for rapid premature contractions (spasm), they were treated with hernia repair (Figure 2B and C). A fundoplication was done for the second patient but not for the third because it was not possible to mobilize the fundus. Neither esophageal lengthening nor myotomy were performed. Subsequently, the second patient had no clinical evidence of spasm after hernia repair. The third patient was asymptomatic 1 month after surgery but presented with chest pain at 2 years. Upper endoscopy revealed a normal esophagus and possible gastroparesis as evidenced by the presence of retained gastric contents. There was no evidence of spasm.

COMMENT

Our results revealed that the presence of a large hiatal hernia may modify the metrics used in assessing EPT studies. Patients with large hiatal hernias had lower mean EGJ pressures, a lower distal contractile integral, slower contractile front velocity, and a shorter DL. These findings might be a consequence of anatomic changes such as the associated shortened esophagus and loss of distal anchoring to the hiatus. However, despite these differences in individual parameters, the final diagnosis and distribution of motility disorders was unaffected by the presence of hernia.

The presence of a large hiatal hernia is challenging for both the performance of catheter placement and the interpretation of EPT studies. In our series, the manometry catheter did not traverse the CD and was coiled in

Table 2. LES or EGJ Pressures

	Median (5th-95th Percentiles)		
	Large Hiatal Hernias		
	Intra-abdominal Pressure Not Recorded (n = 44)	Intra-abdominal Pressure Recorded (n = 46)	Controls (n = 46)
Pressures referenced to atmospheric pressure			
LES/EGJ end expiratory pressure, mm Hg	28.0 (8.3-53.0)	22.0 (4.4-43.0)[a,b]	27.0 (11.7-51.8)
LES/EGJ end inspiratory pressure, mm Hg	38.5 (12.0-59.0)	31.0 (11.4-51.7)[a,b]	38.0 (21.1-66.0)
Pressure referenced to intra-abdominal pressure			
LES/EGJ end expiratory pressure, mm Hg	NA	7.0 (0-30.0)[b]	15.0 (1.5-45.3)
LES/EGJ end inspiratory pressure, mm Hg	NA	12.5 (0-38.0)[b]	22.5 (9.4-50.5)

Abbreviations: EGJ, esophagogastric junction; LES, lower esophageal sphincter; NA, not applicable.
[a] $P < .05$ vs large hiatal hernia intra-abdominal pressure not recorded.
[b] $P < .05$ vs controls.

Table 3. Assessment of LES or EGJ Relaxation

	Median (5th-95th Percentiles)		
	Large Hiatal Hernias		
	Intra-abdominal Pressure Not Recorded (n = 44)	Intra-abdominal Pressure Recorded (n = 46)	Controls (n = 46)
IRP, mm Hg, referenced to intra-abdominal pressure	NA	3.4 (0-8.5)[a]	7.9 (0.3-16.9)
IRP (referenced to intra-abdominal pressure) >15 mm Hg, No. (%)	NA	1 (2)	3 (7)
IRP, mm Hg, referenced to intrahernia pressure	6.4 (0.2-30.7)	0 (0-10.5)[b]	NA
Nadir LES/EGJ pressure referenced to atmospheric pressure	15 (5.5-33.3)	10 (3.4-23.0)[a,b]	12.0 (5.7-21.7)
% LES/EGJ relaxation	57.5 (33.3-80)	65.5 (36.8-80.9)[b]	61.0 (38.0-76.7)

Abbreviations: EGJ, esophagogastric junction; IRP, integrated relaxation pressure; LES, lower esophageal sphincter; NA, not applicable.
[a] $P < .05$ vs controls.
[b] $P < .05$ vs large hiatal hernia intra-abdominal pressure not recorded.

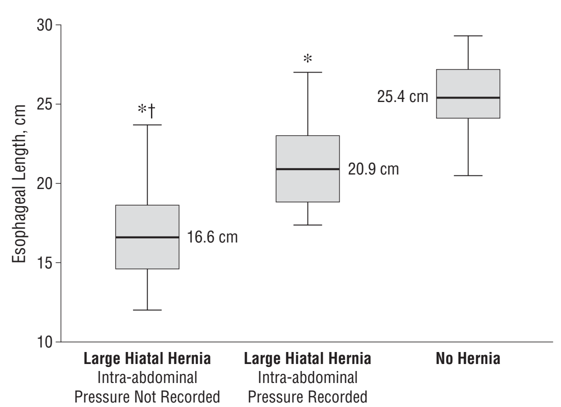

Figure 1. Box plots represent esophageal length in patients with large hiatal hernia and in patients without hernia. Each box has a height equal to the interquartile range; the horizontal bar indicates the median and the error bars represent the minimum and maximal values. *Indicates $P < .01$ vs no hernia; †, $P < .01$ vs large hiatal hernia.

Table 4. Distribution of Esophageal Contractile Patterns in Patients With Large Hiatal Hernia With or Without Intra-abdominal Pressure Recorded and in Patients Without Hernia

	No. (%)		
	Large Hiatal Hernias		
	Intra-abdominal Pressure Not Recorded (n = 44)	Intra-abdominal Pressure Recorded (n = 46)	Controls (n = 46)
Normal peristalsis	23 (52)	19 (41)	23 (50)
Weak peristalsis	14 (32)	17 (37)	13 (28)
Frequent failed peristalsis	4 (9)	4 (9)	3 (7)
Premature contractions	3 (7)	0	1 (2)
Hypertensive peristalsis	0	2 (4)	4 (9)
Rapid contractions	0	4 (9)	2 (4)

the hernia in almost half of the patients with large hiatal hernia. Endoscopic placement was successful in less than half of the patients in which it was attempted. For comparison, endoscopic placement was successful in 90% of patients with achalasia within the same period.

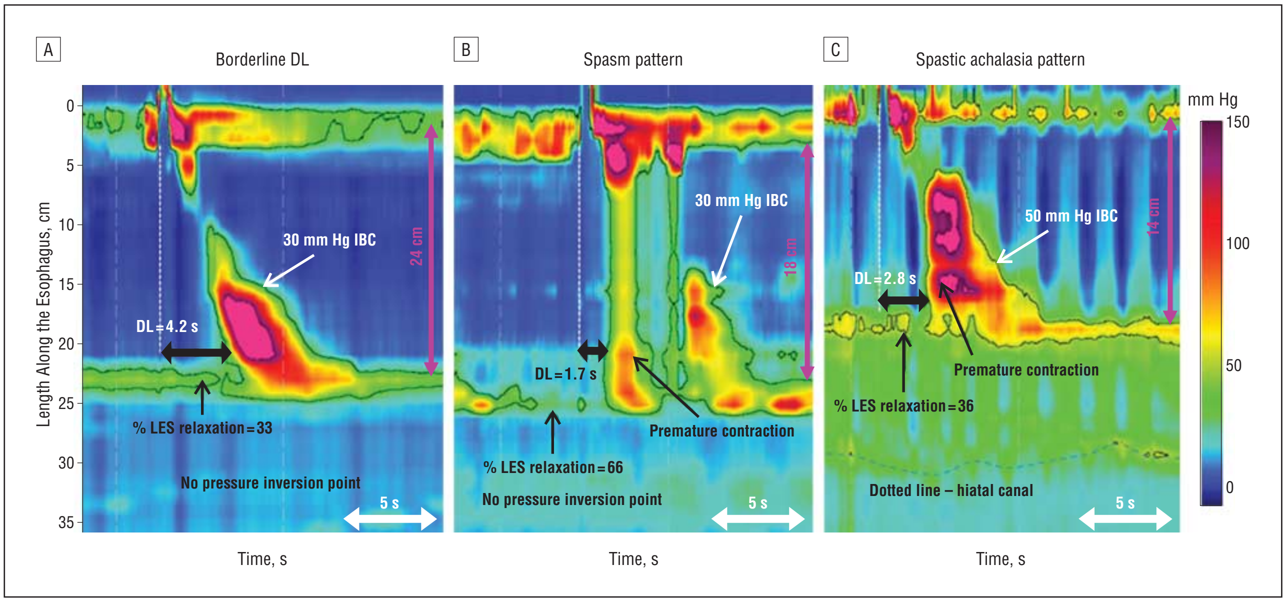

Figure 2. Examples of patients (A-C) with reduced distal latency time (DL) in the context of large hiatal hernia. Intra-abdominal pressure was not recorded in patients A and B. IBC indicates isobaric contour; LES, lower esophageal sphincter.

Anatomic changes in patients with hiatal hernia are certainly responsible for this high rate of failure because the catheter frequently recoils into the hernia after being guided into the distal stomach. Recording intra-abdominal pressure is important in assessing LES relaxation because the normative values for IRP were developed based on a reference to intra-abdominal pressure.[5] Thus, absence of intra-abdominal pressure measurement will preclude normal IRP evaluation based on published normative values. Additionally, the IRP can be altered by the anatomic distortions at the EGJ where EGJ outflow obstruction may occur at the CD in the context of normal LES relaxation.[13] Given these 2 important issues, we assessed measurements of a modified IRP with the distal EGJ pressure reference positioned within the intrahernia. Although this would not be a viable option to assess transit into the subdiaphragmatic stomach, this position would still be a reliable measure of the pressure gradient through the LES into the stomach. Our results suggest that sphincter relaxation can be accurately assessed without intubation into the abdominal cavity.

Interestingly, there were instances where the IRP value was significantly elevated, suggesting outflow obstruction at the LES. However, this abnormality should be interpreted with caution given the fact that the obstruction may not be related to impaired LES relaxation but more likely is a manifestation of anatomic angulation at the EGJ secondary to the intrathoracic position of the stomach. There was a slight increase in the mean IRP value reference to intrahernia pressure in patients with a large hiatal hernia where abdominal intubation could not be accomplished compared with patients with a large hiatus hernia and placement of the catheter into the intra-abdominal cavity. This once again was likely a function of the anatomic distortion related to the hernia and not to impaired LES relaxation as evidenced by the normal percentage of LES relaxation.

Assessment of esophageal peristalsis is also an important component of the preoperative evaluation before surgical repair of the hernia to help rule out achalasia.[14] Even if the assessment of LES relaxation is somewhat altered by anatomic distortion, supportive evidence of achalasia can be assessed by evaluating esophageal peristalsis. Normal peristalsis will exclude achalasia in all but atypical cases, while spasm and absent peristalsis will increase the likelihood of achalasia. The EPT metrics were modified by the presence of large hernias, and premature contractions were overdiagnosed because of the shortened esophageal length and its effect on the calculation of DL. Therefore, a diagnosis of premature contraction and spasm should be made with caution.

Our study did have some limitations because it reflects the practice at a tertiary care center with a large proportion of patients with complex large hiatal hernia. This may explain the elevated rate of manometry catheters coiled in the hernia, as these patients likely represented complicated cases including paraesophageal hernia and volvulus. Additionally, the retrospective design of the study did not allow for complete evaluation of outcomes and no systematic examination or evaluation of symptoms were performed after surgery in cases where surgery was done to determine whether some of the EPT metrics actually improved. However, patients with the most abnormal values were assessed and the abnormalities in these patients were not persistent postoperatively or at subsequent medical record review at points well after the initial HRM.

In conclusion, our study demonstrated that EPT metrics are affected by the presence of large hiatal hernia. Nevertheless, esophageal motility disorders were not more frequent in patients with large hiatal hernia than in patients without hernia. When required for presurgical evaluation, esophageal manometry should be interpreted in a context of the anatomic changes related to the large hernia and its effect on esophageal length and the EGJ. Another important observation of this study was that even if the manometry catheter did not reach the abdominal cavity, esophageal motor function was still evaluable and endoscopic placement should not be required in the majority of patients. However, one should interpret the findings on EPT with caution when proper catheter placement is not confirmed and always attempt to obtain further evidence if a major motor disorder is suspected in the context of a large hernia.

Accepted for Publication: October 28, 2011.
Correspondence: John E. Pandolfino, MD, Northwestern University, Feinberg School of Medicine, Department of Medicine, Division of Gastroenterology, 676 St Clair St, Ste 1400, Chicago, IL 60611-2951 (pandolfino@northwestern.edu).
Author Contributions: *Study concept and design:* Kahrilas and Pandolfino. *Acquisition of data:* Kia and Soper. *Analysis and interpretation of data:* Roman, Kahrilas, Kia, Luger, and Pandolfino. *Drafting of the manuscript:* Roman, Kahrilas, and Pandolfino. *Critical revision of the manuscript for important intellectual content:* Roman, Kahrilas, Kia, Luger, Soper, and Pandolfino. *Statistical analysis:* Roman and Pandolfino. *Obtained funding:* Kahrilas and Pandolfino. *Administrative, technical, and material support:* Kahrilas and Kia. *Study supervision:* Kahrilas, Soper, and Pandolfino.
Financial Disclosure: None reported.
Funding/Support: This work was supported by grants R01 DK56033 (Dr Kahrilas) and R01 DK079902 (Dr Pandolfino) from the Public Health Service.

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INVITED CRITIQUE

What Do the Esophagus and a Jump Rope Have in Common?

The Functional Importance of Anchoring at Both Ends

The association of hiatal hernia and foregut disease emerged in the late 19th century and its association with esophageal mucosal injury, in the 1930s to 1950. The functional consequences of hiatal hernia, however, remain incompletely understood. Roman et al[1] have contributed considerably to the understanding of hiatal hernia; this article continues that trend. It is useful to consider the sphincter (LES) and esophageal body separately to simplify interpretation of the data. Large hiatal hernias have long been shown to lower LES pressure because the CD are an important component of the normal high-pressure zone. The effect of hernia on sphincter relaxation (IRP) is less well studied, although experience with paraesophageal hernias would suggest that complex hernias may impair relaxation. As Roman et al emphasize, however, interpretation is complex. The LES residual pressure is measured in reference to intra-abdominal gastric pressure and a catheter coiled in a large hernia will alter the calculation. This article nicely discusses the complexities of this issue, although detail of the individual patient anatomy in those with elevated IRP is absent,