Measuring Mechanical Properties of the Esophageal Wall Using Impedance Planimetry

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KEYWORDS

- Impedance planimetry • FLIP • Distensibility • Esophagus
- Esophagogastric junction

KEY POINTS

- Impedance planimetry allows accurate measurement of compliance or distensibility.
- Distensibility is a better parameter than pressure alone to evaluate sphincter competence.
- Distensibility of the esophagogastric junction (EGJ) is increased in gastroesophageal reflux disease patients and normalized by fundoplication.
- Untreated achalasia patients have a lower distensibility of the EGJ than well-treated achalasia patients and healthy volunteers.
- In achalasia, EGJ distensibility correlates with symptom severity and may therefore play a potentially important role in the clinical management of achalasia.
- Functional lumen imaging probe technology may provide valuable perioperative information on EGJ distensibility during Heller myotomy, peroral endoscopic myotomy, and antireflux surgery.

INTRODUCTION

The esophagus is a muscular tube, serving as a conduit between the oral cavity and the stomach with its principle role to transport ingested material toward the stomach. At its distal end, the lower esophageal sphincter (LES) is continuously contracted to

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prevent reflux of gastric contents. Sphincter competence and more specific competence of the esophagogastric junction (EGJ) involve a complex interaction between LES tone, diaphragmatic contraction during the respiratory cycle, and the valvular effect caused by the sling fibers. More than 40 years ago, Harris and Pope[1] identified that resistance to distension by measurement of radial force rather than sphincter pressure should be the prime determinant of sphincteric strength. Hence, measuring pressure and cross-sectional areas (CSA) of the EGJ would be a better parameter to evaluate sphincter competence. Conversely, transport of intraluminal contents across the EGJ is largely determined by the diameter of the EGJ.[2] Pandolfino and colleagues[2] indeed elegantly demonstrated that volume flow across the EGJ can be estimated by using a simplified mathematical model based on Newton's law of motion. From this model, it is evident that flow is highly dependent on the diameter of the EGJ, given that it is factored to the 4th power in the equation of the mathematical model. Based on these findings, it is becoming increasingly clear that not basal pressure generated by the EGJ but rather its ability to open or distend is the main determinant of flow, in either antegrade or retrograde direction. Hence, clinical tools measuring distensibility may prove to be more useful to assess the function of the EGJ.

EARLIER METHODS TO MEASURE DISTENSIBILITY

In 2002, Pandolfino and colleagues[2] elegantly combined distension of the EGJ using a barostat balloon with barium swallow images to assess the EGJ distensibility. The balloon pressure was set at 5 mm Hg and was subsequently increased in 2-mm Hg increments until opening of the EGJ was noted fluoroscopically. In addition, the diameter of the EGJ was assessed during 5-mL dilute barium swallows at different barostat balloon pressures. Distensibility was then defined as the relationship between the EGJ diameter (measured by barium swallow) and balloon distension pressure. This technique was performed in 8 healthy volunteers and 9 reflux patients with a hiatal hernia. The distensibility of the EGJ was significantly increased in gastroesophageal reflux disease (GERD) patients with a hiatus hernia such that the opening occurred at a significantly lower distension pressure and that for a given distention pressure the resultant opening diameter was on average 0.5 cm wider.

The underlying hypothesis for measuring the compliance of the EGJ during LES relaxation was that the observed increased diameters in hernia patients would both qualitatively and quantitatively determine retrograde gastroesophageal flow. Using a mathematical model based on Newton's law of motion, it is indeed evident that flow is highly dependent on diameter, given that it is factored to the 4th power. Furthermore, using this model together with the pressure and diameter measurements described above, estimations for esophagogastric flow across the EGJ for water and air were made for healthy volunteers as well as GERD patients with a hiatal hernia. The flow for either air or water was 2-fold to 3-fold greater for the hernia group compared with normal subjects at each value of gastroesophageal pressure gradient. Within each group, flow of air is about 2 orders of magnitude greater than the flow of water. Thus, the lower opening pressure and 0.5-cm increase in EGJ diameter observed in hernia patients coupled with the difference in viscosity between water and air make a normal individual capable of venting large volumes of gas from the stomach at low pressure with minimal potential for liquid reflux, whereas hernia patients will vent large volumes of air or water at similar pressures. A correlate of this is that the volume of refluxate is also uniformly higher among hernia patients. Taken together, this study of Pandolfino[2] showed that measuring opening patterns and distensibility can be an indicator of the status of the junction in health or disease.

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