Esophageal Function Testing

Beyond Manometry and Impedance

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KEYWORDS

• Manometry • Achalasia • Impedence • Esophagus
• Longitudinal muscle esophagus • US imaging esophagus

KEY POINTS

- Manometry and impedance provide information regarding circular muscle function and luminal content respectively.
- Ultrasound imaging provides a unique perspective of esophageal function by providing important information regarding longitudinal muscle contraction, coordination between the two muscle layers of muscularis propria and esophageal distension during bolus transport.
- Laser Doppler assessment of perfusion may be an important complementary tool to assess blood perfusion of esophageal wall as a possible mechanism of pain.

INTRODUCTION

Endoscopy, barium swallow, high-resolution manometry (HRM), pH measurement (either catheter based or using Bravo system), and impedance monitoring of the esophagus are major esophageal function testing techniques that are available in most academic centers and centers of excellence for esophageal function testing. These recording techniques provide key information on the sensory and motor functions of the esophagus that allows one to treat patients based on the physiologic understanding of the patient's symptoms. Another esophageal function testing technique, which even though has not gained wide popularity and acceptance, is ultrasound (US) imaging of the esophagus using either catheter-based intravascular US imaging probe or US endoscope. The latter is suited for anatomic/morphologic information of the esophageal muscle and identification of lesions that affect esophageal

Financial Support: This work was supported by National Institutes of Health Grant R01DK060733.
Conflict of Interest: Author has no conflict of interest.
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Gastrointest Endoscopy Clin N Am 24 (2014) 667–685
http://dx.doi.org/10.1016/j.giec.2014.06.006
giendo.theclinics.com
1052-5157/14/$ – see front matter Published by Elsevier Inc.

function by compression of the esophagus. On the other hand, catheter-based US imaging provides information on anatomy/morphology as well as functional aspects of esophageal muscle function. In order for US imaging, especially dynamic US imaging, to gain popularity it will have to be user friendly and less expensive. To date, dynamic US imaging has only been used in research laboratories. There is no question though that the static and dynamic US imaging, using either US endoscopes or catheter-based US probes, provides key information of esophageal functions that is unparallel to any other technique.

Laser Doppler blood perfusion measurement of the esophageal wall is another important modality, especially if future testing confirms that "noncardiac" chest pain and proton pump inhibition (PPI)-resistant heartburn are related to low blood perfusion or relative ischemia of the esophageal wall. The goal of this writing is to provide principles underlying these techniques and to update the status of information that these techniques have yielded.

ULTRASOUND IMAGING OF ESOPHAGUS

The esophagus is no exception—like the rest of the gastrointestinal tract, its outer muscular coat or muscularis propria is organized into an outer longitudinal and an inner circular muscle layer. Recent studies prove that the longitudinal muscles of the esophagus play an important role in the physiology and pathophysiology of the sensory and motor function of the esophagus and one can study longitudinal muscle function using dynamic US imaging. The esophageal longitudinal muscle starts proximally as 3 bundles: (1) a main longitudinal muscle bundle that originates from the posterior surface of the cricoid cartilage, (2) an accessory muscle bundle from the posterolateral surface of cricoid cartilage, and (3) an accessory muscle bundle from the contralateral surface of the cricopharyngeus muscle. Muscle bundles from the 2 sides quickly fan out to surround the entire circumference of the esophagus, leaving only a triangular space, the area of Laimer that is not surrounded by the longitudinal muscle at the most cranial end of the esophagus. At the caudal end, longitudinal muscle fibers continue into the stomach and some may be inserted in the circular muscle bundles of the lower esophageal sphincter (LES). Contraction of the longitudinal muscles causes axial shortening of esophagus. Circular muscles of the esophagus do not travel in a perfectly circular fashion along the length of the esophagus, instead they are oriented in the helical fashion, especially in the distal part of the esophagus.[1–3] The angle of these helices increases as one goes toward the distal direction. Because of the helical morphology of circular muscle,[3] part of the axial esophageal shortening during peristalsis is the result of circular muscle contraction. Unlike circular muscle contraction and relaxations, which can be easily recorded by intraluminal pressure probes/manometry, it is difficult to measure contraction and relaxation of the longitudinal muscle. Dynamic US imaging provides information on the local longitudinal muscle contraction and axial shortening of the esophagus.[4]

In the animal experiments, longitudinal muscle contraction can be recorded by surgically implanted strain gauges in the long axis of the esophagus.[5] Longitudinal muscle contraction can also be recorded by radio-opaque markers implanted in the long axis of esophagus (in humans[6,7] and animals[8]) in combination with radiographic fluoroscopy, which records motion of the radio-opaque markers as a proxy of longitudinal muscle contraction. Clearly, these studies have provided important information; however they are of limited use for the human experimentation for several obvious reasons: (1) strain gauze implantation is not practical and (2) radiation exposure for prolonged recordings limits use of radio-opaque marker