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Endoscopic aspects in diagnosis of gastroesophageal reflux disease and motility disorders: Bravo, capsule, and functional lumen imaging probe

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ABSTRACT

Catheter-based testing remains the current standard of practice for the diagnosis of gastroesophageal reflux disease and esophageal motility abnormalities. Ambulatory pH testing and esophageal manometry have been in use for the past 40 years, but with the development of high-resolution manometry and multichannel intraluminal impedance testing, catheter-based testing has undergone significant recent technological improvement. Nonetheless, these tests continue to have limitations. In the case of ambulatory reflux testing, patient discomfort and limited activity remain significant problems. For esophageal manometry, methodological issues limit its ability to evaluate the function of the esophagogastric junction in normal and diseased states. In recent years, several new diagnostic tools have been developed to address the shortcomings of catheter-based testing. The wireless pH probe has been available for clinical use for more than 10 years, is better tolerated than catheter-based testing, and provides longer monitoring periods. Esophageal capsule endoscopy has undergone clinical evaluation for gastroesophageal reflux disease and Barrett esophagus with mixed results. Functional lumen imaging probe testing is a new technology that is still undergoing clinical evaluation but holds promise as a complimentary method for evaluating esophageal physiology, in particular esophagogastric junction function.

1. Introduction

Diagnostic testing for gastroesophageal reflux disease (GERD) and esophageal motility disorders has relied primarily on the traditional, catheter-based pH and manometric techniques for more than 40 years. Recent refinements to both these techniques have greatly expanded our esophageal motility diagnostic capabilities. High-resolution esophageal manometry (HRM) with pressure topography has added to our understanding of esophageal physiology and led to a new classification system for esophageal motility disorders. Esophageal multichannel intraluminal impedance testing now allows us to quantify non–acid reflux events, as well as acid events, and it decreases the number of false-positive tests [1]. These tests remain the standard for diagnosis of GERD and esophageal motility disorders, though as catheter-based tests, they remain within the domain of specialized esophageal motility laboratories.

Over the past decade, we have witnessed the development and approval of 3 novel, non–catheter-based devices designed to evaluate esophageal physiology and aid in the diagnosis of GERD and esophageal motility disorders: wireless pH capsule (Bravo, Given Imaging, Yokneam, Israel), esophageal capsule endoscopy (PillCam ESO, Given Imaging, Yokneam, Israel), and functional luminal imaging probe (EndoFLIP, Crospon Medical Devices, Galway, Ireland). These 3 devices have expanded our diagnostic armamentarium for esophageal disorders and perhaps begun the migration of esophageal function testing out of the specialized esophageal motility laboratories and into the endoscopy suite.

This article focuses on the endoscopic aspects of these new technologies and their role in the diagnosis of GERD and esophageal motility disorders. Some of these tools have been in use for more than 10 years and have achieved well-established roles in esophageal testing. However, clinical experience with the other devices is limited and their clinical utility continues to evolve.

2. Gastroesophageal reflux disease and endoscopy

The Montreal consensus group defined GERD as a condition that develops when the reflux of stomach contents causes troublesome symptoms or complications or both [2]. Though heartburn and regurgitation are considered classic GERD symptoms, neither

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symptom has sufficiently high sensitivity (30%-76%) or specificity (62%-96%) in diagnosing esophagitis found on endoscopy [3]. Consequently, endoscopy is often undertaken early in the evaluation of a patient with symptoms consistent with GERD as findings of esophagitis or intestinal metaplasia provide a high degree of specificity in diagnosing abnormal reflux [4]. Endoscopy is an important diagnostic test in a patient who is refractory to medical therapy to exclude evidence of chronic mucosal abnormalities including rings, strictures, and eosinophilic esophagitis (EoE). It is important to note that as many as two-thirds of patients with GERD have normal endoscopic findings on endoscopy [5], and the sensitivity of endoscopy as a diagnostic tool for GERD is significantly lowered in the setting of active acid suppression [6].

3. Wireless pH capsule: Bravo

3.1. Background

With the development and approval in 2001 of the wireless pH monitoring system (Bravo), gastroenterologists gained an alternative method to catheter-based pH testing for detection of distal esophageal acid exposure. Conventional catheter-based pH monitoring systems are limited by several methodological limitations that may influence the ability to detect pathologic acid reflux. These limitations include, but are not limited to, placement of a conspicuous nasal catheter that may lead to patient avoidance of reflux-inducing activities [7], migration of the recording instrument potentially altering esophageal acid detection [8], and the need to manometrically determine the correct location of the lower esophageal sphincter (LES). The wireless pH system has several advantages over the conventional catheter-based pH monitoring: enhanced patient compliance, an immovable monitoring site, and the ability to extend the monitoring period beyond 24 hours [9]. The capsule has a typical battery life of 48 hours but recording times can be extended by exchange of the batteries or potentially in the near future with a capsule with an extended 96-hour recording time.

3.2. The wireless pH monitoring system

The Bravo monitoring system uses a radiotelemetry pH recording capsule that attaches to the esophageal wall to measure distal esophageal acid exposure. The pH capsule is oblong in shape, measures $6 \times 5.5 \times 25\ mm^3$ in size, has an antimony pH electrode and reference electrode located at its distal tip, and contains an internal battery and transmitter. Data from the pH sensor are recorded at 6-second sampling intervals and are transmitted to an external receiver carried by the patient via a radiofrequency signal every 12 seconds. The capsule is preloaded onto a delivery system with linear measurements, which allows for placement of the capsule at a predetermined location within the distal esophagus [9,10]. The capsule also contains a well, located on the superior-lateral aspect of the probe, which allows for capsule attachment to the esophageal wall (Figure 1).

Correct placement of the wireless probe typically requires endoscopic identification of the squamocolumnar junction (SCJ). Prior investigations have shown the SCJ is located approximately 1-1.5 cm distal to the proximal border of the LES as measured by esophageal manometry [11]. As the convention in catheter-based pH testing calls for pH measurement in the distal esophagus at a point 5 cm above the proximal border of the LES, the wireless pH probe is attached 6 cm proximal to the SCJ. Though endoscopy-guided placement is most commonly used, the wireless pH capsule may be placed transorally with the aid of transnasal manometric measurement of the location of the most proximal border of the LES. The capsule should be placed 5 cm proximal to the upper border of the LES, but correct placement using this technique requires a correction factor of approximately 3.74 cm applied to the LES location measurement [12], which takes into account the longer distance that the manometry catheter traverses through the nasopharynx. It should be noted that the wireless pH capsule delivery system has been used for both transnasal and transoral passage of the capsule into the esophagus. However, prior reports have documented significant patient discomfort with transnasal passage with intubation failure rates greater than 10% and a significant rate (86%) of epistaxis [13]. Consequently, deployment of the wireless capsule via the transnasal route should be discouraged.

Fig. 1. Bravo pH monitoring system. Photograph courtesy of Given Imaging (Yokneam, Israel). (Color version of figure is available online.)

For successful capsule deployment, the patient should be positioned in the left lateral decubitus position. The capsule comes prepackaged on the end of a specialized delivery system consisting of an 80-cm long, 6-Fr tubular device with a tapered distal tip surrounding the capsule and a handle on the proximal end. The tubular delivery system contains measurement markings to correctly identify the distance of the catheter from the level of the incisors. A minimal amount of lubrication should be applied to the distal end of the delivery system, taking note to avoid placing a large amount of lubrication near the well in the capsule, which may interfere with capsule mucosal attachment. The capsule is advanced through the oropharynx, taking note to ensure the tapered end surrounding the capsule is oriented posteriorly to guide the device along the hard palate, posterior oropharynx, and upper esophageal sphincter. Once located in the correct position within the distal esophagus, suction is applied to the suction port on the handle of the catheter, and the surrounding esophageal mucosa is suctioned into the capsule well. Successful mucosal engagement within the well is assumed when the vacuum pressure records a value greater than 510 mm Hg for a period of 10 to 15 seconds. Once this is achieved, the safety device on the spring-loaded handle is removed, and the piston should be fully depressed. This action fires a stainless steel metal pin tangentially through the well within the capsule, capturing the esophageal mucosa and securing the capsule to the esophageal wall. Once the activation button is fully depressed, it should be rotated clockwise 90° to secure the pin in place and then re-extended along the same