The Role of Novel Functional Probes in the Evaluation and Treatment of Esophageal Disease

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KEYWORDS

• Esophageal physiology • Gastroesophageal reflux disease • GERD • Achalasia
• Eosinophilic esophagitis • Functional lumen imaging probe • Mucosal impedance • Manometry

KEY POINTS

- Effective treatment of esophageal disease relies on a multifaceted evaluation of esophageal anatomy, physiology, and histology.
- The functional lumen imaging probe (FLIP) and mucosal impedance (MI) catheter are two novel technologies that can be used to evaluate esophageal function in a variety of disease states.
- FLIP uses impedance planimetry to measure the esophageal anatomy and determine the distensibility index (ie, resistance of the esophagus and esophagogastric junction to radial stretch).
- MI directly measures the impedance to electrical current through the esophageal mucosal surface. MI has been found to correlate with dilated intercellular spaces and other histologic changes caused by esophageal disease.

INTRODUCTION

The history of the treatment of esophageal disease over the last 100 years has been marked by technological advances that have greatly improved both diagnostic capabilities and the efficacy of therapeutic interventions. Advances in radiology, including contrast esophagram, CT, and PET, have allowed for a more granular assessment of esophageal anatomy and accurate detection and staging of malignant disease. In the late 1960s and 1970s, the development and rapid proliferation of flexible endoscopy radically altered the landscape of diagnosis and treatment of both benign and malignant esophageal disease.[1] Not only could the entire lumen of the esophagus and stomach be easily and safely visualized for assessment of anatomy and pathology but endoscopically based interventions could also be performed. Therapies, such as varied percutaneous endoscopic gastrostomy tube placement for feeding access, radiofrequency ablation for dysplastic Barrett esophagus and early cancer, band ligation of esophageal varices, and per-oral endoscopic myotomy (POEM) for achalasia, have dramatically reduced the invasiveness and morbidity of the treatment of these diseases.

The use of sensors and probes has also greatly enhanced our understanding of esophageal physiology and disease, and allowed for the accurate and objective diagnosis of a range of conditions. The introduction of conventional, and then high-resolution, manometry (HRM) allowed for the

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scientific study of esophageal physiology and the nuanced diagnosis of a range of esophageal motility disorders, including achalasia.[2] The development of the 24-hour pH-monitoring catheter by Johnson and Demeester[3] in the 1970s enabled the objective assessment of gastroesophageal reflux (GER), allowing for a more precise and effective utilization of both medical and surgical therapies. The introduction of a wireless pH monitoring probe further reduced the patient discomfort associated with testing.[4]

In the past 10 years, the development and study of 2 novel esophageal measurement probes has further added to the armamentarium of clinicians evaluating and treating patients with esophageal disease. The functional lumen imaging probe (FLIP) and mucosal impedance (MI) catheter both use electrical impedance measurements to objectively assess properties of esophageal anatomy, physiology, and even histology. This review serves as an introduction to these two measurement devices and discusses the current evidence supporting their use in the diagnosis and treatment of a variety of esophageal diseases.

FUNCTIONAL LUMEN IMAGING PROBE

Functional Lumen Imaging Probe Technology

FLIP is a catheter-based device that is inserted transorally, usually with patients under moderate sedation or anesthesia in the setting of an upper endoscopy or surgical procedure. The distal end of the catheter shaft contains 16 electrode pairs spaced at fixed intervals (ranging 5–10 mm in current commercially available models [Crospon; Galway, Ireland]) over a span of 8 cm or 16 cm (Fig. 1). The segment of the catheter that contains these electrodes is housed within an infinitely compliant plastic bag that can be variably inflated with saline solution using the device controls. Excitation electrodes at either end of the catheter emit a continuous low electric current, and impedance planimetry measurements are taken between each of the electrode pairs. These measurements are translated to cross-sectional areas (CSAs) at the level of each electrode pair using Ohm's law. These CSAs can then be combined to create a graphic representation of luminal anatomy that can be viewed in real time on the device display (Fig. 2).[5] A solid-state sensor measures pressure within the bag. FLIP has been most commonly used to measure the anatomy and function of the lower esophageal sphincter (LES) and esophageal body; but studies assessing its use for the upper esophageal sphincter, sphincter of Oddi, and anal sphincter have also been performed.[6–8] The most-studied FLIP measure of LES physiology is distensibility index (DI), which is calculated by dividing the minimum CSA (ie, narrowest point of the LES) by intrabag pressure. More recent studies have graphed CSA measurements (y-axis) over time (x-axis) to create FLIP topography plots, similar to the pressure topography plots used to display and analyze HRM measurements (Fig. 3). These topography graphs have enabled the use of FLIP to detect normal and abnormal esophageal contractions that occur in response to the volumetric distention caused by FLIP bag inflation, and represent a novel method for assessing esophageal motility.

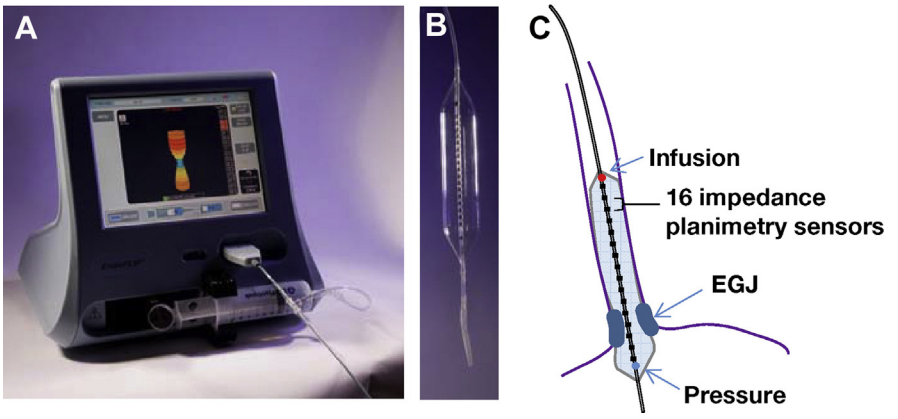

Fig. 1. The FLIP device and control console display (*A*) a graphic representation of esophageal lumen geometry. (*B*) A photograph and (*C*) cartoon of the FLIP measurement catheter are shown. The tip of the catheter contains 16 impedance planimetry electrodes and a pressor sensor, housed within a variably inflatable bag into which saline solution can be infused. EGJ, esophagogastric junction. (*From* Hirano I, Pandolfino JE, Boeckxstanes GE. Functional lumen imaging probe for management of esophageal disorders: expert review from the clinical practice updates committee of the AGA Institute. Clin Gastroenterol Hepatol 2017;15(3):325–34; with permission.)