SHORT COMMUNICATION

Esophageal Manometry: Fundamentals and Diagnostic Insights

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Introduction

The primary function of the gastrointestinal (GI) system is secretion and motility. Upper and lower GI endoscopy assesses the structural part, whereas the motor function of the GI tract and sphincters is assessed by manometry. High-resolution manometry (HRM) is the current gold standard diagnostic method used for evaluating esophageal motility disorders. In the 1990s, Ray Clouse introduced HRM for conventional esophageal manometry, and in the 2000s, it was recognized as a diagnostic tool in evaluating esophageal motor disorders.[1]

Studying GI motor function in normal and diseased states is crucial for understanding the pathophysiology and developing the management protocols for dysmotility. Various diagnostic modalities such as radiology, manometry, scintigraphy, and intraluminal electrical impedance monitoring are used to evaluate GI motor activity. These methods are complementary to each other, providing unique and valuable insights. Esophageal manometry remains the cornerstone for the assessment of esophageal motor functions as it is the most direct, sensitive, accurate, reliable, and objective method.[2]

Esophageal manometry is usually ordered by physicians to evaluate dysphagia, assess the pattern of esophageal peristalsis before fundoplication, esophagogastric junction outflow obstruction (EGJOO) disorders, as well as for symptoms like chest pain due to noncardiac causes, odynophagia, nausea/vomiting, or typical symptoms of gastroesophageal reflux disease (GERD) (i.e., heartburn, regurgitation, chronic cough, etc.).[3]

HRM Systems

High-resolution manometry systems are of two types: (1) Water-perfusion system with 22, 24, or 36 channels and (2) solid-state manometry (SSM) system having 36 channels (sensors) (Fig. 1).[4]

Esophageal manometry evaluates esophageal peristalsis by recording the amplitude, pattern, and force of contractile events that take place in the body of the esophagus and sphincters at rest and during the swallow episodes. The visual presentation of acquired data has facilitated the improved understanding of analysis and interpretation of esophageal motor function. Pressure sensors are placed along the length of the manometry catheter, which transmits intraluminal esophageal pressure signals to a receiving device, where the data are recorded and displayed.[5] Esophageal pressure topographical (EPT) analysis has enabled a better understanding of esophageal motility disorders.

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Principle

In the water-perfusion system, the catheter consists of multiple fine plastic tubes with side ports positioned at specific intervals along its length. Water perfusion takes place continuously through these tubes at a fixed rate to maintain a constant internal pressure. During esophageal peristalsis, compression of a side port interrupts water flow, causing a measurable pressure change within that tube, which is displayed on the color plot. In contrast, solid-state systems incorporate pressure sensors positioned at regular intervals along a flexible catheter. Their key advantage is the ability to detect rapid pressure changes with high temporal resolution. The pressure data from both systems are interpolated and displayed as a two-dimensional topographic contour plot, where concentric bands represent color-coded pressure gradients according to a defined scale.[6]

Procedure

The HRM procedure involves the intranasal insertion of the catheter in a fasting patient positioned supine. The catheter is advanced and positioned across the esophagogastric junction (EGJ) using the pull-through technique, ensuring that both the upper esophageal sphincter (UES) and lower esophageal sphincter (LES) are simultaneously visible on the color plot. Once proper placement is confirmed, baseline UES and LES pressures are recorded for 30 seconds without any swallowing. The patient is then instructed to perform a 5 mL water swallow (wet swallow), followed by a 30-second recording period before the next swallow. This interval ensures that the LES returns to its baseline pressure and that deglutitive inhibition does not interfere with esophageal motility. A minimum of 10 wet swallow recordings is obtained.

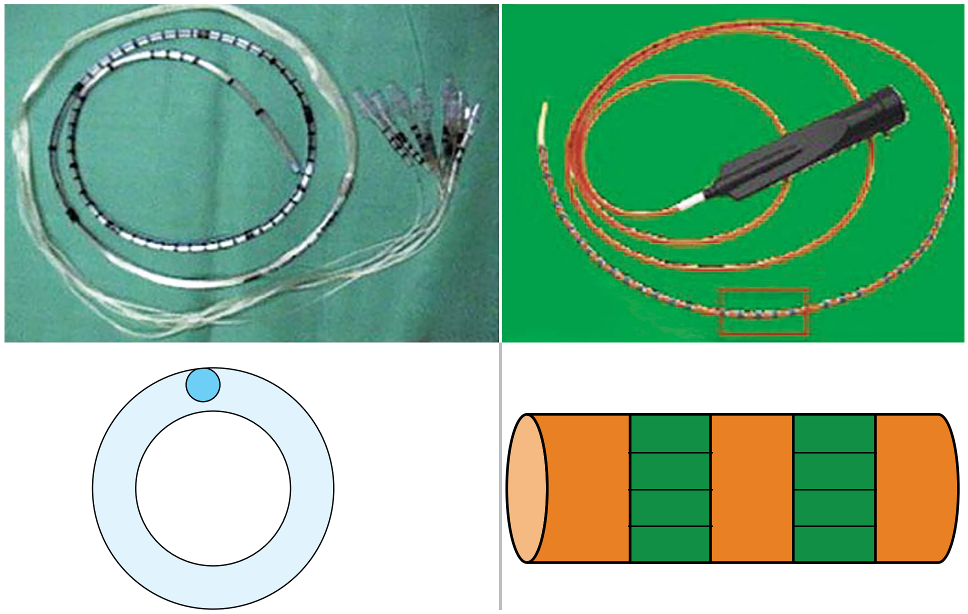

Fig. 1: Water perfusion and solid-state HRM catheters

Technical difficulties encountered during the procedure include improper catheter positioning, which can result in inaccurate pressure measurements; catheter migration or displacement during the test, leading to artifacts or loss of critical data; calibration errors, as pressure sensors require precise calibration and any drift can compromise results; and artifacts caused by patient movement, coughing, or talking, which may mimic or obscure genuine contractions or sphincter responses.[7]

Esophageal manometry is generally a safe procedure, though some patients may experience mild discomfort during the test. Common side effects include temporary nasal or throat irritation, nausea, and occasional minor nasal bleeding.

Chicago Classification

The introduction of HRM led to the development of new objective parameters and a novel classification system known as the Chicago classification (CC). CC was first introduced in 2007 and updated in 2021 to version 4.0 (CCv4.0), which provides a framework for classifying esophageal motility and EGJ disorders.[7]

Analysis

Analysis of esophageal pressure topography includes the assessment of basal sphincter pressures, integrity of the EGJ, peristaltic contractions, and pressurization. The HRM metrics—integrated relaxation pressure (IRP), distal contractile integral (DCI), contractile deceleration point, and distal latency (DL)—described below help to quantify esophageal function objectively. HRM employs sensors placed at 1 cm intervals, which provides detailed spatial and temporal resolution of pressure variations.

Basal UES and LES Pressures

The first step in esophageal manometry interpretation is identification of the upper and lower esophageal sphincters with sphincter relaxation during swallowing along the luminal axis, which is represented as a separate high-pressure zone or pressure band (Fig. 1).

Basal pressures of the sphincters are noted by placing the cursors appropriately over the pressure bands. Normally in the EGJ, the crural diaphragm is directly placed over the LES, which is identified during inspiration, whereas in hiatus hernia, there exists a complete separation between the LES and crural diaphragm.[8]

The normal value of basal LES pressure ranges from 10 to 30 mm Hg, and for UES, it is 30–80 mm Hg.

Low LES pressure indicates GERD, while high pressure is seen in achalasia or nutcracker esophagus (Fig. 2).[9]

Integrated Relaxation Pressure

Integrated relaxation pressure is defined as the minimum EGJ pressure measured over a 4-second period (contiguous or noncontiguous) within the first 10 seconds after swallowing, following deglutitive UES relaxation. It assesses the adequacy of EGJ relaxation with swallowing. Normal value is <15 mm Hg.

An elevated IRP is a characteristic finding of achalasia and other esophageal motor disorders.[10]

Contraction Deceleration Point

The contraction deceleration point (CDP) denotes the point along the length of the esophagus where the velocity of peristaltic contraction becomes slow, reflecting the emptying of the bolus into the stomach. It can also be marked three cm above the LES.

Distal Latency

Distal latency reflects the timing of peristalsis and is defined as the interval from the onset of UES relaxation to the CDP. It also gives information about the period of deglutitive inhibition. The normal value is >4.5 seconds.

Peristaltic Breaks

Peristaltic breaks refer to gaps within the 20 mm Hg isobaric contour of the peristaltic contraction between the UES and EGJ.

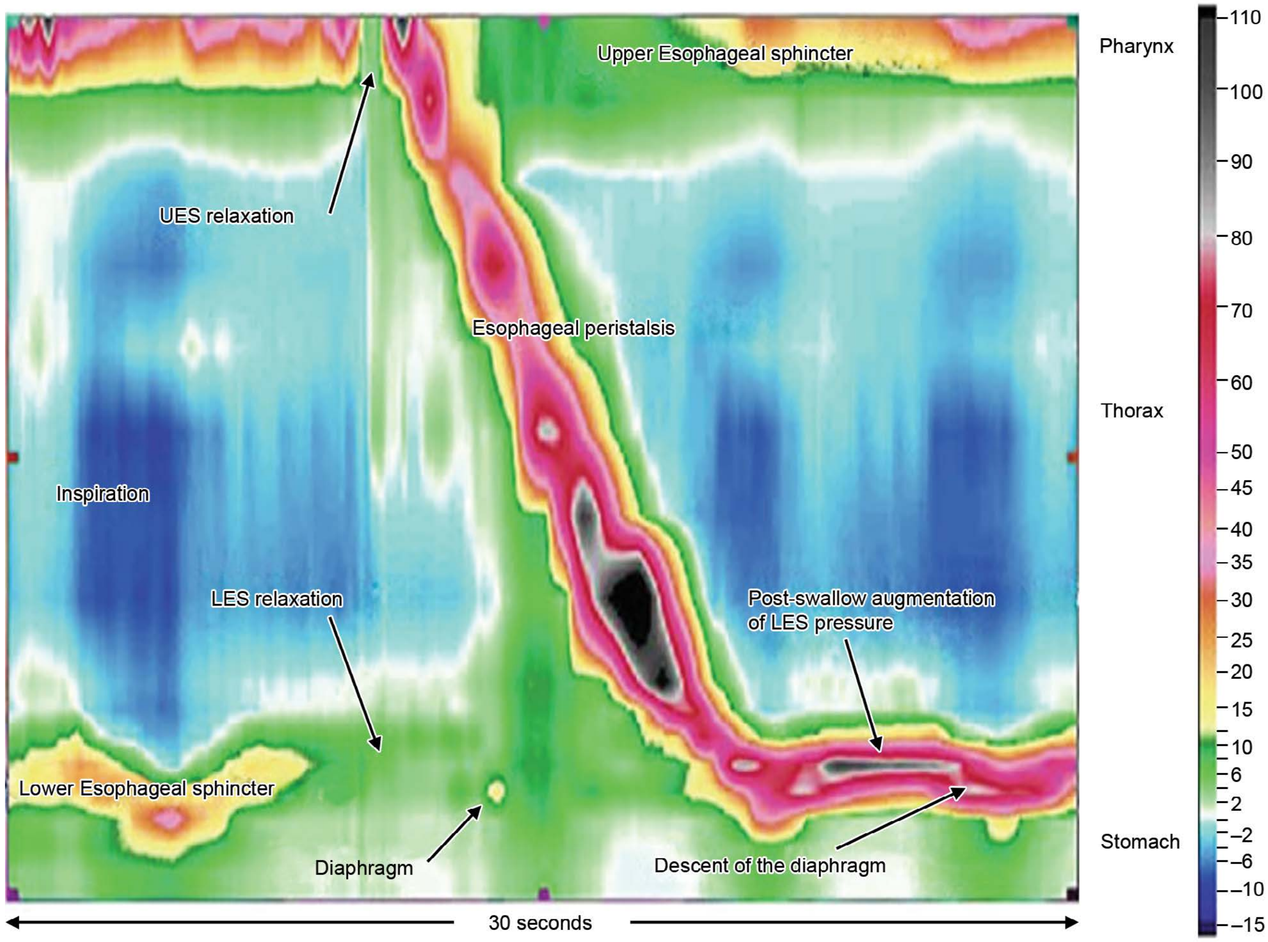

Fig. 2: Normal esophageal manometry recording

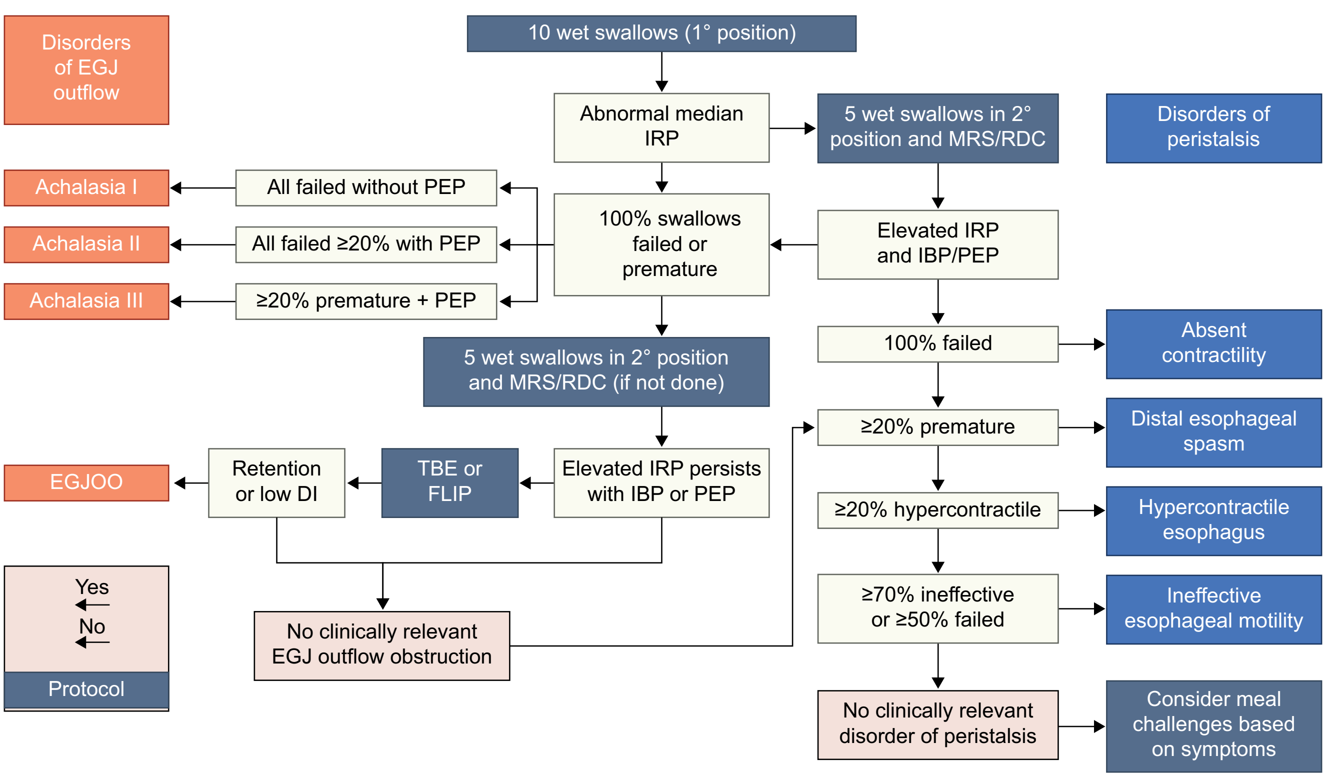

Fig. 3: Chicago classification v4.0 algorithm and protocol

Distal Contractile Integral

Distal contractile integral represents the effectiveness of esophageal peristaltic contractions. It measures the strength, duration, and length of esophageal contraction in the distal segment.

Normal value ranges between 450 and 8000 mm Hg·s·cm.

A low DCI represents ineffective esophageal motility, while a high DCI indicates esophageal spasm.[11]

Peristaltic Contractions

Peristaltic contractions can be classified based on DCI values:[12]

- Failed peristalsis: DCI <100 mm Hg·s·cm.
- Weak peristalsis: DCI >100 mm Hg·s·cm, but <450 mm Hg·s·cm.
- Ineffective: Failed peristalsis or weak peristalsis or peristaltic break >5 cm in the setting of a DCI ≥450 mm Hg·s·cm.
- Hypercontractile: DCI >8000 mm Hg·s·cm.

Pressurization Patterns

Pressurization is represented as straight, vertical bands of elevated pressure spanning from the upper to the LES, forming an isobaric pressure column along the esophageal length. When this pressurization involves the whole esophagus, it is referred to as Panesophageal Pressurization. If it is limited to the distal or proximal region, it is called compartmentalized pressurization.

The hierarchical algorithmic approach outlined in CCv4.0[13] is summarized in Figure 3.

The catheter may itself influence pressure readings. As a foreign body, it can provoke transient changes in sphincter tone or esophageal motility due to mucosal irritation or reflex responses. These effects are typically minor, but they will be considered and adjusted while interpreting the results.

Conclusion

High-resolution manometry has enhanced better understanding of esophageal motor function in health and disease. It has also refined the CC, which is gradually evolving. Moreover, the advancements in high-resolution technology have enabled clinicians to diagnose and draw up the management plan for a wide range of esophageal motility disorders.

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