Review Article

High-Resolution Manometry in Esophageal Motility Disorders: Latest Clinical Evidence and the Impact of Chicago Classification Version 4.0

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Abstract

High-resolution manometry (HRM) has fundamentally transformed the diagnosis and management of esophageal motility disorders (EMDs) by providing detailed, spatiotemporal pressure topography and offers a superior evaluation of esophageal function compared to conventional manometry. HRM interpretation is standardized by the Chicago Classification (CC). The clinical landscape has evolved significantly with the introduction of CC version 4.0 (CCv4.0) and complementary technologies. This review article provides an updated synthesis of HRM in clinical practice, incorporating the latest evidence. It discusses key changes introduced in CCv4.0, such as the expanded protocol with provocative maneuvers (Multiple Rapid Swallows and Rapid Drink Challenge) and a refined diagnostic framework for achalasia, esophago-gastric junction outflow obstruction (EGJOO), and peristaltic abnormalities. The article also explores the critical pre-operative role of HRM before anti-reflux surgery and its utility in evaluating refractory GERD symptoms. Furthermore, it addresses the growing importance of combining HRM with adjunct technologies like FLIP, barium radiography to enhance diagnostic confidence, especially in challenging cases. Finally, the review outlines current limitations, such as symptom correlation for minor disorders, and discusses future perspectives in the field.

Keywords: High-resolution manometry, Chicago Classification 4.0, esophageal motility disorders, achalasia, EGJ outflow obstruction, provocative maneuvers, functional lumen imaging probe.

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Introduction:

High-resolution manometry (HRM) has become the gold standard for assessing esophageal motor function since its clinical introduction.[1] Unlike conventional manometry, which relies on a few widely spaced pressure sensors, HRM utilizes a high density of pressure transducers to generate a continuous, color-coded pressure map, known as esophageal pressure topography (EPT). This enhanced resolution has enabled a more precise characterization of esophageal motility, leading to improved diagnostic accuracy and the identification of distinct EMD phenotypes.[2] The interpretation of HRM studies is standardized by the Chicago Classification (CC), a hierarchical framework that has been regularly updated by international experts to incorporate new research findings.[3] The latest iteration, CCv4.0 was published in 2021 and marks a paradigm shift from a purely metric-based classification to a more integrated, clinically-oriented diagnostic approach (Figure-I).[4]

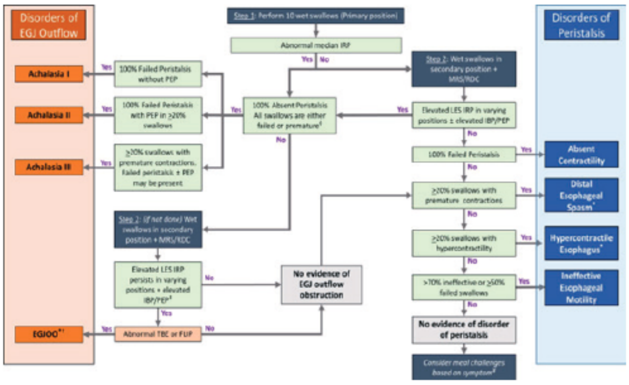

Figure I: Chicago Classification 4.0 Hierarchical Classification Scheme[19]

This update introduces a more robust protocol, emphasizing provocative maneuvers and clinical correlation, which is crucial for translating manometric findings into meaningful clinical decisions.[5] This review article aims to provide a comprehensive overview of the latest clinical evidence related to HRM. We will discuss the key technical aspects of HRM, detail the major changes in CCv4.0 and their clinical implications, and explore the role of HRM in diagnosing specific EMDs. Furthermore, we will examine the integration of complementary technologies and address the current limitations and future perspectives of HRM in gastroenterology.[6]

2. The Impact of Chicago Classification Version 4.0

The Chicago Classification (CC) v4.0 was developed to address several shortcomings of earlier versions, particularly regarding the need for greater diagnostic certainty and clinical correlation.[3] The updated protocol (Figure-II) expands beyond the standard 10 supine liquid swallows to include additional maneuvers that provide more comprehensive physiological data.[7]

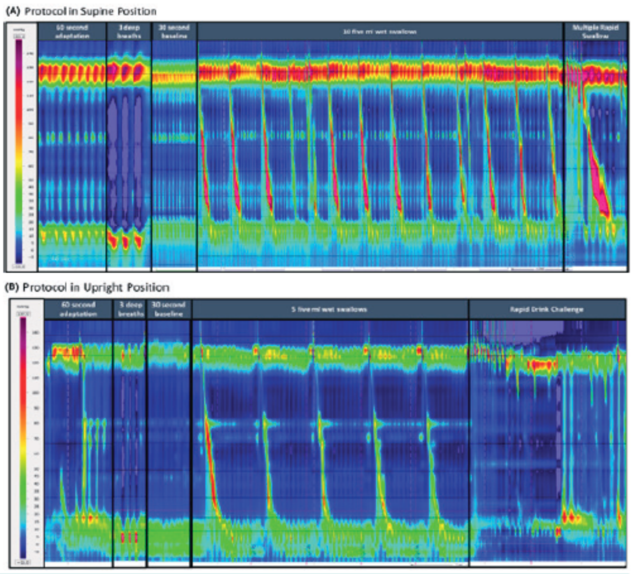

Figure II: High-resolution manometry images depicted the standard protocol.

A, The supine position includes a 60 second adaptation period, 3 deep breaths, 30 second baseline period, 10 five ml wet swallows and at least one multiple rapid swallow.

B, Position is changed to the upright position followed by a 60 second adaptation, 3 deep breaths, 30 second baseline period, 5 five ml wet swallows, and a rapid drink challenge [19]

2.1. Disorders of EGJ Outflow: Refining the Diagnosis of Achalasia

CCv4.0 has further refined the subtyping of achalasia, a disorder characterized by impaired LES relaxation and absent peristalsis (Figure-III). While the three classic subtypes (I, II and III) are retained, the diagnostic criteria have been tightened.

Type I (Classic): Requires a median integrated relaxation pressure (IRP) > upper limit of normal (ULN) and 100% failed peristalsis (Distal Latency [DL] > ULN but Distal Contractile Integral [DCI] < 100 mmHg•s•cm).

Type II (with Pan-esophageal Pressurization): Requires pan-esophageal pressurization in ≥20% of swallows, a more stringent threshold than the previous ≥2 swallows, to improve diagnostic consistency.[4,8]

Type III (Spastic): Defined by the presence of ≥20% premature contractions (DL < 4.5 s) with a median IRP > ULN.

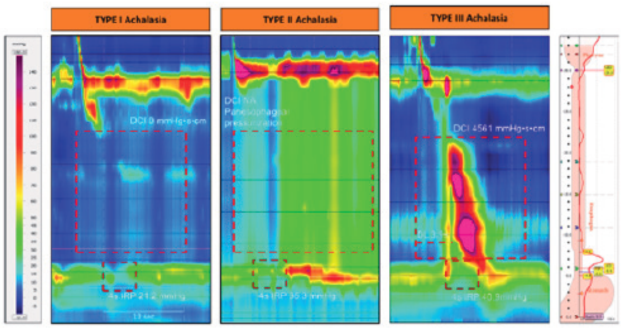

Figure III: Achalasia Subtypes. Type I Achalasia: integrated relaxation pressure (IRP) is elevated with failed peristalsis (DCI) <100 mmHg-s-cm), and without panesophageal pressurization. Type II Achalasia: IRP is elevated with failed peristalsis and panesophageal pressurization. Type III Achalasia: IRP is elevated with a normal DCI, and a reduced distal latency.[19]

2.2. Major Motility Disorders: Absent Contractility and its Specificity

The diagnosis of "absent contractility" is now reserved for instances where there is 100% failed peristalsis and a normal median IRP. Crucially, CCv4.0 explicitly links this diagnosis to the clinical context of systemic diseases, most notably scleroderma.4 This emphasizes that absent contractility is not an idiopathic condition but is strongly associated with connective tissue disorders, guiding appropriate patient evaluation and management.

2.3. The Introduction of the "Inconclusive" Category

Recognizing that not all manometric findings are clear-cut, CCv4.0 formally introduces an "Inconclusive" category. This applies to studies with borderline metrics (e.g., IRP just above the ULN without supporting evidence for EGJOO) or inconsistent patterns.4 This category prompts the clinician to seek additional information, often through provocative testing, rather than forcing a potentially incorrect diagnosis. (Figure-IV)

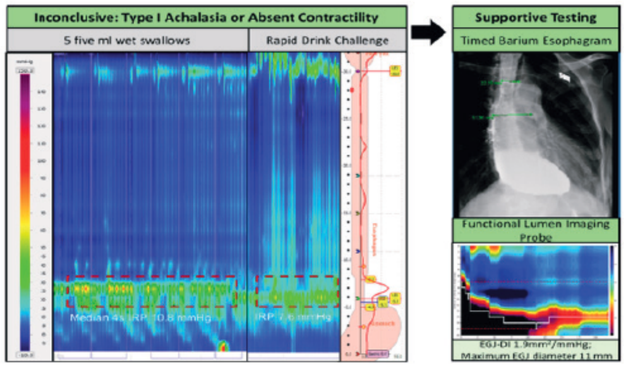

Figure IV: Inconclusive Diagnosis for Achalasia or Absent Contractility requires supportive Testing with timed barium esophagram and/or functional lumen imaging probe (FLIP). Here, the timed barium esophagram demonstrates a dilated distal esophagus with barium retention. On FLIP,the esophagogastric junction (EGJ) distensibility index (EGJ-DI) is reduced, maximal EGJ diameter is reduced and there is absent contractile response to distension.[19]

A major update is the introduction of **"EGJ Outflow Obstruction (EGJOO)"** as a distinct, potentially clinically relevant diagnosis, rather than a manometric finding of uncertain significance. CCv4.0 mandates that an elevated IRP must be accompanied by supporting evidence of obstruction, such as symptoms of dysphagia, evidence of retention on timed barium swallow, or a dilated esophagus on endoscopy.[4,9] This prevents over-diagnosis of inconsequential findings. (Figure-V)

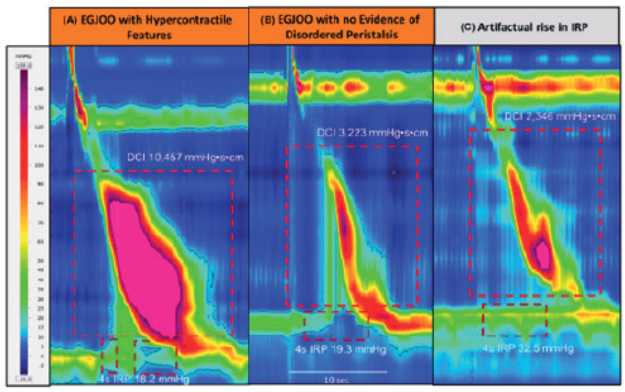

Figure V: EGJOO subtypes: A) EGJOO with hypercontractile features: IRP is elevated with intrabolus pressurization and hypercontractile swallow. B) EGJOO with no evidence of disordered peristalsis: IRP is elevated with normal contractile vigor. C) Manometric EGJOO related to artifactual rise in IRP: IRP is elevated in the absence of intrabolus pressurization and is likely associated with artifact.[19]

2.4. Enhanced Role of Provocative Maneuvers

CCv4.0 places greater emphasis on the use of provocative maneuvers during HRM to uncover latent motility abnormalities and assess esophageal reserve function.[10]

Multiple Rapid Swallow (MRS): This test assesses the integrity of neuromuscular inhibition and subsequent peristaltic augmentation. A normal response is inhibition during the swallows followed by a augmented contraction (post-MRS DCI > the mean single-swallow DCI). Its role in predicting outcomes following therapy for achalasia (e.g., peroral endoscopic myotomy, POEM) is an area of active research.[11]

Rapid Drink Challenge (RDC): Involves rapid ingestion of a liquid bolus (e.g., 200 mL). It is highly sensitive for detecting EGJ outflow obstruction, often eliciting a pan-esophageal pressurization in achalasia that may not be apparent on single water swallows.[12]

Standardized Test Meal: The use of a solid test meal (e.g., a 4-cm rice cake) during HRM can reproduce symptoms like dysphagia that are not present during liquid swallows. This "post-prandial HRM" can identify meal-induced abnormalities and is particularly useful in patients with symptoms out of proportion to standard HRM findings.[13]

3. Clinical Evidence and Impact on Management

The refinements in CCv4.0 are directly supported by clinical evidence that links manometric patterns to pathophysiology and treatment outcomes.

Achalasia Subtyping and Treatment Selection: The prognostic value of achalasia subtyping is well-established. Type II achalasia has the best response to any therapy (pneumatic dilation, Heller myotomy, or POEM), while Type I may require more aggressive myotomy, and Type III, characterized by spasticity, often responds best to POEM due to its ability to extend the myotomy proximally.[8,14]

Clarifying EGJOO: The stricter criteria for EGJOO help distinguish true, clinically significant obstructions (e.g., from early achalasia, strictures, or eosinophilic esophagitis) from pseudo-obstructions caused by hiatal hernia or repetitive swallowing. This prevents unnecessary invasive procedures in patients with a benign manometric finding.[9]

Hypercontractile Esophagus and Distal Esophageal Spasm (DES): CCv4.0 maintains the distinction between hypercontractile esophagus (Jackhammer esophagus) and DES based on the presence of premature contractions. This is clinically relevant as the two disorders may respond differently to smooth muscle relaxants or neuromodulators.[4]

3.2 Evaluation of Refractory GERD and Non-cardiac Chest Pain:

In patients with persistent symptoms despite optimal medical therapy, HRM can uncover underlying EMDs that mimic GERD or cause non-cardiac chest pain.[15]

Refractory GERD: HRM helps exclude achalasia and identifies disorders like IEM that may contribute to impaired acid clearance. It also characterizes EGJ morphology and contractility, which can have implications for reflux pathophysiology.[7]

Chest Pain: HRM can diagnose spastic EMDs like hypercontractile esophagus or distal esophageal spasm that may be responsible for non-cardiac chest pain.[5]

3.3 Pre-operative Assessment for Anti-reflux Surgery:

HRM is an indispensable tool before fundoplication. It helps to:[16]

• Identify contraindications, such as achalasia or absent contractility, which would lead to post-operative dysphagia.
• Determine the integrity of peristalsis, which can influence the choice between a partial or a full fundoplication.
• Characterize the EGJ morphology, providing insights into the presence and type of hiatal hernia.

4. Complementary Technologies: HRM, FLIP, and HRIM:

The diagnostic landscape is moving toward a multimodal approach, where HRM is often complemented by other technologies to enhance diagnostic confidence.[17]

4.1 Functional Lumen Imaging Probe (FLIP)

FLIP provides real-time information about the distensibility and contractility of the EGJ and esophageal body. This is particularly valuable in cases where HRM findings are inconclusive or discordant with patient symptoms. (Figure-IV) For example, FLIP can reveal impaired EGJ distensibility in some patients with EGJOO, providing objective confirmation of outflow obstruction.[16]

4.2 High-Resolution Impedance Manometry (HRIM)

HRIM combines pressure and impedance sensing, providing information on bolus transit in addition to pressure activity. This offers a more complete picture of esophageal function, as it can identify bolus clearance abnormalities even in cases with seemingly normal peristalsis on standard HRM.[17]

5. Limitations:

Despite its clear advantages, HRM is not without limitations. A significant challenge remains the poor correlation between minor manometric abnormalities (e.g., IEM) and clinical symptoms. This highlights the need for careful clinical assessment alongside manometric interpretation, a point underscored by CCv4.0.[18]

6. Acknowledgement:

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7. Conclusion

High-resolution manometry, interpreted through the robust framework of the Chicago Classification, remains the cornerstone of modern esophageal motility evaluation. The introduction of CCv4.0, with its expanded protocol and emphasis on clinical correlation, has further strengthened HRM's role in clinical practice. The integration of provocative maneuvers and complementary technologies like FLIP and HRIM allows for a more comprehensive assessment of esophageal function, leading to more accurate diagnoses and better-informed treatment decisions. While challenges persist in fully correlating certain findings with patient symptoms, the evolution of HRM and its adjuncts promises to continue improving the diagnostic and therapeutic approach to esophageal motility disorders.

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