Overview of gastrointestinal motility testing

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INTRODUCTION

Disorders of gastrointestinal (GI) transit and motility are common, and can affect one or more regions of the GI tract [1]. This topic will review the indications, technique, and interpretation of the results for commonly performed tests to evaluate GI tract motility [2]. Specific motility disorders are discussed in detail elsewhere. (See "Distal esophageal spasm and hypercontractile esophagus" and "Achalasia: Pathogenesis, clinical manifestations, and diagnosis" and "Gastroparesis: Etiology, clinical manifestations, and diagnosis" and "Chronic intestinal pseudo-obstruction: Etiology, clinical manifestations, and diagnosis" and "Etiology and evaluation of chronic constipation in adults" and "Fecal incontinence in adults: Etiology and evaluation".)

ESOPHAGUS

Esophageal manometry — Esophageal manometry assesses intraluminal esophageal pressures, peristalsis, and bolus transit.

Indications

Dysphagia — In patients with esophageal dysphagia in whom upper endoscopy is unrevealing, esophageal manometry can diagnose an underlying esophageal motility disorder [3]. In patients with oropharyngeal dysphagia of unclear etiology, manometry helps to determine the underlying cause and can identify patients with oropharyngeal dysphagia who may benefit from surgical myotomy. (See "Oropharyngeal dysphagia: Clinical features,

diagnosis, and management" and "Approach to the evaluation of dysphagia in adults", section on 'Approach to diagnostic testing'.)

Gastroesophageal reflux disease management — The most important role of esophageal manometry in patients with gastroesophageal reflux disease (GERD) is prior to antireflux surgery. Manometry serves to exclude an alternative diagnoses, such as scleroderma or achalasia, for which antireflux surgery may be contraindicated. In addition, manometry may lead to a modification of the surgical approach or a change in management; however, this is controversial. Esophageal manometry is not diagnostic for GERD and manometry cannot predict disease severity [4]. Non-specific manometric findings that may be seen in patients with GERD include impaired peristalsis, decreased peristaltic amplitude, hypotensive lower esophageal sphincter, and excessive transient relaxations. (See "Clinical manifestations and diagnosis of gastroesophageal reflux in adults", section on 'Esophageal manometry' and "Surgical treatment of gastroesophageal reflux in adults".)

Noncardiac chest pain — GERD is the most common cause of noncardiac chest pain. Esophageal manometry should be performed to exclude an esophageal motility disorder in patients who fail to respond to eight weeks of proton pump inhibitor therapy for empiric treatment of GERD. (See "Evaluation of the adult with chest pain of esophageal origin", section on 'Diagnostic evaluation'.)

Technique — Esophageal manometry is most commonly performed using high resolution manometry (HRM). HRM catheters use a higher number of pressure sensors (available in 20 to 36 channels) separated by 1 cm as compared with conventional manometry, which uses catheters with four to eight pressure sensors spaced at 3 to 5 cm intervals (figure 1). HRM has a high accuracy for assessing pressure changes, especially in the sphincters, as compared with conventional manometry [5,6]. HRM is, therefore, the preferred manometric technique for the assessment of esophageal motility [7-9]. (See "High resolution manometry".)

The esophageal manometry catheter is a long, flexible tube that is placed in the patient's esophagus such that the distal tip of the catheter lies in the stomach.

Patient protocol — Once the manometric catheter is positioned, the patient undergoes a 10-swallow protocol in the supine or semi-upright position consisting of 10 swallows, each using 5 mL of water. A number of centers also perform 5 or 10 additional swallows with the patient in the upright position. Additional maneuvers such as multiple rapid swallows or rapid drink challenge may increase confidence for a manometric disorder [10].

Analysis and interpretation — Manometric evaluation using HRM involves assessment of peristalsis and upper and lower esophageal sphincter pressures.

- **Upper esophageal sphincter** – The major elements of the analysis of upper esophageal sphincter (UES) include the following:
  - Degree of UES relaxation as measured by the nadir UES pressure, referenced to hypopharyngeal pressure
  - Magnitude of the intrabolus pressure, as a measure of the resistance to flow across the UES
  - Presence or absence of pharyngeal peristalsis
- **Esophageal body motor function** – Esophageal motor function is assessed by the propagation of the pressure waves and the contractile vigor of the pressure waves [11]. Propagation of the pressure waves is assessed as either peristaltic or non-peristaltic contractions (ie, spastic or simultaneous) contractions.
- **Lower esophageal sphincter** – Analysis of LES function involves determination of its location, basal pressure, and degree of relaxation:
  - LES location is measured as the distance from the nares
  - Proximal margin of the LES is the distance at which intraesophageal pressure is first recorded
  - LES pressure is measured relative to gastric pressure

HRM utilizes esophageal pressure topography (EPT) to define esophageal motor function, and the corresponding measures in conventional manometry are listed in the table (table 1). Three-dimensional HRM is an emerging technology that may be helpful in assessing the LES and UES where the musculature is asymmetrical [7]. Analysis and interpretation of high resolution manometry metrics is discussed in detail separately. (See "High resolution manometry", section on 'Analysis' and "High resolution manometry", section on 'Classification of motility disorders by esophageal pressure topography (EPT)'.)

Functional lumen imaging probe (FLIP) — This technology utilizes impedance planimetry during balloon distention to assess luminal distensibility (ie, cross-sectional area in relation to pressure). The distensibility index has been best established for the lower esophageal sphincter in assessment of achalasia but has also been used in the esophageal body and pylorus. Endoflip is a commercially available system that utilizes this technology. This system includes a flexible catheter with 16 impedance planimetry sensors surrounded by a highly compliant balloon. The catheter with the balloon deflated is passed at the time of endoscopy and then, when in the appropriate position confirmed endoscopically, the balloon is filled with fluid and a distensibility

index is calculated. Pressure and diameter of the balloon during distention is also recorded. This technology may provide useful information in patients with EGJ outflow obstruction and those patients in whom achalasia is suspected.

STOMACH

Indications — Indications for assessment of gastric emptying include [12]:

- Unexplained nausea and/or vomiting
- Persistent dyspepsia despite proton pump inhibitors therapy and normal upper endoscopy
- Poor glycemic control despite treatment for diabetes mellitus
- Suspected dumping or stasis syndrome following gastric surgery
- Refractory gastroesophageal reflux disease
- Suspected chronic intestinal pseudo-obstruction
- (See "Approach to the adult with nausea and vomiting" and "Approach to the adult with dyspepsia", section on 'Evaluation of persistent symptoms' and "Bariatric operations: Late complications with subacute presentations", section on 'Dumping syndrome' and "Approach to refractory gastroesophageal reflux disease in adults", section on 'Initial assessment' and "Diabetic autonomic neuropathy", section on 'Gastrointestinal autonomic neuropathy'.)

Gastric scintigraphy — The most commonly performed test to evaluate gastric emptying is gastric scintigraphy. This test involves ingestion of a test standard meal (typically >200 kcal) labeled with a radioactive isotope (99mTc for solids and 111 Indium for liquids) and measurement of the percentage of gastric emptying after one, two, and four hours after ingestion. Although the severity of symptoms does not always correlate with the rate of gastric emptying, delayed gastric emptying has been classified based on the extent of gastric retention on scintigraphy at 4 hours. Excessively fast gastric emptying may be associated with dyspeptic symptoms in some patients. Scintigraphic gastric emptying is discussed in detail, separately. (See "Gastroparesis: Etiology, clinical manifestations, and diagnosis".)

13C breath testing — 13C-labeled acetate, octanoic acid breath tests, or spirulina (a plant-based protein source) have been used to assess gastric emptying [13-15]. Most studies suggest that the accuracy of these breath tests in normal and pathologic conditions is less than that of scintigraphic measurements of gastric emptying [13,16,17]. Breath tests for gastric emptying are discussed in detail, separately. (See "Gastroparesis: Etiology, clinical manifestations, and diagnosis", section on 'Alternatives to scintigraphy'.)

Wireless motility capsule — The wireless motility capsule is an alternative to gastric scintigraphy and can also assess gastrointestinal transit time in other parts of the gastrointestinal tract. (See 'Wireless motility capsule' below.)

Other — Specialized motility tests such as antroduodenal manometry and electrogastrography are not widely performed and their role in clinical practice has not been well established. These tests are discussed separately. (See "Gastroparesis: Etiology, clinical manifestations, and diagnosis", section on 'Gastroduodenal manometry' and "Gastroparesis: Etiology, clinical manifestations, and diagnosis", section on 'Other tests'.)

SMALL BOWEL AND COLON

Indications — Indications for small bowel and colon motility testing include chronic constipation, chronic diarrhea, dyspepsia, chronic idiopathic intestinal pseudoobstruction, scleroderma, and malabsorption. Radio-opaque marker study can only assess colonic motility whereas scintigraphy and wireless motility capsule can be used to assess gastric, small bowel, and colon transit times [18].

Radiopaque marker study — The radiopaque marker study is commonly performed by measuring movement of radiopaque markers through the gut. Several different approaches have been used, including single or multiple marker ingestion [19]. Both these methods provide a quantitative assessment of colonic transit [20,21].

Technique — While abstaining from laxatives, enemas, and medications that may affect bowel function for two to three days prior to the test, radiopaque markers are ingested, and their passage through the colon is monitored by abdominal radiographs. Markers are counted in the right, left, and rectosigmoid colons (defined by certain anatomical landmarks) and are followed as they move distally until expelled [22]. For routine clinical purposes, a single capsule with 24 markers is administered on day 1 and followed by single radiograph on day 6 (after 120 hours) (image 1). However, these tests are not standardized and cannot measure regional transit time.

Analysis and interpretation — Retention of more than five markers (ie, >20 percent) in the colon on day 6 is considered abnormal. Markers progress normally through the proximal colon but stagnate in the rectum in those with outlet delay. Transit in the right colon or left colon is delayed in patients with slow transit constipation. As patients with dyssynergic defecation may also retain markers, a diagnosis of slow transit constipation should only be made after

excluding dyssynergia. (See "Etiology and evaluation of chronic constipation in adults", section on 'Etiology and pathophysiology'.)

Wireless motility capsule — Wireless motility capsule (WMC) is a method of assessing regional (gastric emptying, small bowel transit, and colonic transit) and whole gut transit times (figure 2) [23-26]. The WMC also provides information about gastrointestinal (GI) contractility, such as the frequency of contraction, amplitude of contractions, and motility indexes, for which reference values are available for the gastric and proximal small bowel regions [27]. It is particularly useful for testing individuals with suspected alterations of GI motility in multiple regions [1].

The WMC is an ingestible, wireless capsule (26 x 13 mm) with a battery life of at least five days that measures pressure, pH, and temperature as it traverses the GI tract [25,28]. Gastric emptying of the wireless motility capsule appears to occur with the Phase III migrating motor complex, signifying completion of the postprandial phase and return of the fasting state [29]. It assesses small bowel transit time by a sharp increase in pH on entry into the duodenum and by a fall in pH at the ileocecal junction. However, in 15 percent of patients, this pH drop is not observed and this may be related to the ileocecal valve incompetence [30].

The sensitivity and specificity of the WMC is comparable to radiopaque marker test and scintigraphic gastric emptying in diagnosing slow transit constipation and delayed gastric emptying, respectively [23,24,31]. WMC is well tolerated, has good compliance, and avoids the risks of radiation exposure. However, the WMC is expensive, and it is not clear that it provides added clinical value in most patients.

ANORECTUM

Anorectal manometry — Anorectal manometry assesses anal sphincter and rectal pressure and function.

Indications — Indications for anorectal manometry include:

Fecal incontinence — Loss of continence can result from dysfunction of the anal sphincters, abnormal rectal compliance, decreased rectal sensation, or a combination of any of these abnormalities [32,33]. Anorectal manometry can diagnose functional sphincter weakness and can detect abnormal rectal sensation. (See "Fecal incontinence in adults: Etiology and evaluation", section on 'Etiology and pathogenesis'.)

Constipation — Anorectal manometry may be useful in constipated patients in whom non-mechanical causes of obstructive defecation are suspected [34]. However, the physiology of defecation and the correlation between manometric findings and other objective measures of anorectal function are not completely understood [35]. Furthermore, psychologic factors may influence test results in the laboratory setting. Thus, optimal patient selection for anorectal manometry in the evaluation of constipation is not well established. (See "Etiology and evaluation of chronic constipation in adults".)

Biofeedback therapy — Anorectal manometry can be used to guide biofeedback therapy in patients with non-mechanical causes of obstructive defecation [36,37]. Randomized trials suggest that biofeedback appears to be the preferred treatment for dyssynergic defecation in adults and is superior to the use of laxatives in these patients [38-40]. Overall, success rates are in the range of 70 to 80 percent. (See "Management of chronic constipation in adults", section on 'Biofeedback'.)

Other indications for biofeedback therapy include patients with fecal incontinence due to weakness of the external anal sphincter or decreased ability to perceive rectal distension because of nerve injury. In such patients, biofeedback therapy may improve fecal incontinence by enhancement of the ability to perceive rectal distension and improved coordination of the sensory and strength components that are required for continence. However, there are limited data to support biofeedback in patients with fecal incontinence. (See "Fecal incontinence in adults: Management", section on 'Biofeedback'.)

Technique — Similar to esophageal manometry, water-perfused, and solid-state catheters exist for measuring anorectal motility [41]. Each permits measurements of anal sphincter pressure, rectal compliance and sensation, and anorectal inhibitory reflex, which comprise the essential components of anorectal manometry. High resolution manometry (HRM) is generally preferred as there is no manipulation necessary of the catheter once in place. Three-dimensional HRM anorectal manometry, which has 256 sensors located circumferentially spanning the anal sphincter, has the advantage of assessing for regional defects in the anal sphincter, which may be particularly helpful in patients with fecal incontinence.

Patient protocol — Protocols for anorectal manometry vary widely [42], although there have been efforts to standardize testing [43]. An oral bowel preparation is usually not required [44]. However, an enema is recommended if stool is detected on a digital rectal examination. With the patient in the left lateral position with knees and hips bent at a 90 degree angle, the lubricated probe is gently inserted into the rectum. The probe is oriented with its dorsal aspect corresponding to that of the patient. This allows for detailed reading of measurements from the rectum and anal canal with respect to probe orientation. Anal resting pressure is generally

measured over 20 seconds. The patient is asked to squeeze the anus for as long as possible, for a maximum of 30 seconds. The patient is asked to bear down as if to defecate in order to assess changes in anal and rectal pressures and cough to measure rectoanal reflex activity.

Analysis and interpretation — Anorectal manometry should include an assessment of the following parameters [44-46]:

- **Anal sphincter function** – Anal sphincter function is assessed by measurement of resting sphincter pressure, squeeze sphincter pressure, and the functional length of the anal canal. Maximum resting anal canal tone predominantly reflects internal anal sphincter function, while voluntary anal squeeze pressure reflects external anal sphincter (EAS) function.

  - **Maximal resting anal pressure** – Resting anal pressure is defined as the difference between intrarectal pressure and the highest recorded anal sphincter pressure at rest, and is generally recorded 1 to 2 cm from the anal verge.

    Resting anal pressure is dependent on sex and age. The maximal resting sphincter pressure is significantly lower in women and decreases with age. High anal resting pressure may suggest smooth muscle or striated muscle spasm and often occur in patients with anal fissure or anal pain. Low resting anal pressures may be due to internal or external sphincter injury or a patulous anal canal.

  - **Maximum squeeze pressure** – Maximum squeeze pressure is defined as the difference between the intrarectal pressure and the highest pressure that is recorded at any level within the anal canal during the squeeze maneuver.

    Decreased squeeze pressures may be due to patient noncompliance or weakness of the EAS due to muscle or nerve injury. Weak squeeze pressures have a low sensitivity for identifying sphincter injury or a patulous anal canal but higher specificity in detecting EAS or puborectalis muscle injury or a patulous anal canal.

  - **Functional anal canal length** – Functional anal length is defined as the length of the anal canal over which resting pressure exceeds that of the rectum by greater than 5 mmHg or, alternatively, as the length of the anal canal over which pressures are greater than half of the maximal pressure at rest. It is unclear if longer functional anal canal length is associated with a more effective continence mechanism.

- **Rectoanal reflex activity** – Rapid distention of the rectum induces a transient increase in rectal pressure, followed by a transient increase in anal pressure associated with EAS

contraction (the rectoanal contractile reflex), and in turn, a more prolonged reduction in anal pressure due to relaxation of the internal anal sphincter (the rectoanal inhibitory reflex [RAIR]). The rectoanal contractile reflex is a compensatory guarding mechanism that allows a positive anorectal pressure gradient to be maintained during transient increases in intra-abdominal pressure (eg, coughing) and is essential for preserving continence.

In patients with fecal incontinence, anal sphincter pressure is not increased over the intra-abdominal pressure during coughing. RAIR is absent in several conditions, including dysganglionosis, postcircular myotomy, and lower anterior resection.

- **Rectal sensation** – Rectal sensation is evaluated by measuring the lowest volume of air that evokes sensation and a desire to defecate, and the maximum tolerable volume. Rectal sensation may also be abnormal in patients with fecal incontinence.

- **Changes in anal and rectal pressures during attempted defecation** – The normal response to attempted defecation consists of an increase in rectal pressure and a relaxation of the EAS. Anal manometry in patients with dyssynergic defecation demonstrates impaired relaxation or inappropriate contraction of the pelvic floor muscles and/or inadequate propulsive forces during simulated evacuation. This response can be quantified using the defecation index = maximum rectal pressure during attempted defecation/minimum anal residual pressure during attempted defecation (normal defecation index >1.5).

Four types of dyssynergic defecation are recognized:

- Type 1 – Paradoxical increase in anal sphincter pressure during attempted defecation with normal adequate pushing force
- Type 2 – Inadequate pushing force but paradoxical anal contraction
- Type 3 – Adequate pushing force, but has absent or incomplete (<20 percent) sphincter relaxation
- Type 4 – Inadequate rectal push effort and inadequate anal sphincter relaxation (<20 percent)

SUMMARY AND RECOMMENDATIONS

- Esophageal manometry assesses intraluminal esophageal pressures, peristalsis, and bolus transit. Esophageal manometry is most useful in evaluating symptoms of dysphagia and noncardiac chest pain, and prior to antireflux surgery for gastroesophageal reflux disease. (See 'Esophageal manometry' above and 'Indications' above.)

- Esophageal manometry may be performed using conventional manometry or high resolution manometry (HRM). The main difference between the two manometric systems is the number of pressure sensors found on the esophageal catheters. HRM catheters use a higher number of pressure sensors (available in 20 to 36 channels) separated by 1 cm as compared with conventional manometry, which uses catheters with four to eight pressure sensors spaced at 3 to 5 cm intervals (figure 1). (See 'Technique' above.)

- Both HRM and conventional manometry aim to characterize peristalsis and esophagogastric junction function. The HRM metrics utilized in esophageal pressure topography to define esophageal motor function and the corresponding measures in conventional manometry are listed in the table (table 1). (See 'Analysis and interpretation' above.)

- Indications for assessment of gastric emptying include (see 'Stomach' above and 'Indications' above):

  - Unexplained nausea and/or vomiting
  - Persistent dyspepsia despite proton pump inhibitors therapy and normal upper endoscopy
  - Poor glycemic control despite treatment for diabetes mellitus
  - Suspected dumping or stasis syndrome following gastric surgery
  - Refractory gastroesophageal reflux disease
  - Suspected chronic intestinal pseudoobstruction

- The most commonly performed test to evaluate gastric emptying is gastric scintigraphy. This test involves ingestion of a test standard meal labeled with a radioactive isotope and measurement of the percentage of gastric emptying after one, two, and four hours after ingestion. Although the severity of symptoms does not always correlate with the rate of gastric emptying, delayed gastric emptying has been classified based on the extent of gastric retention on scintigraphy at four hours. (See 'Gastric scintigraphy' above.)

- Indications for small bowel and colon motility testing include chronic constipation, chronic diarrhea, dyspepsia, chronic idiopathic intestinal pseudoobstruction, scleroderma, and malabsorption. Radio-opaque marker study can only assess colonic motility, whereas scintigraphy and wireless motility capsule can be used to assess gastric, small bowel, and colon transit times. (See 'Small bowel and colon' above.)

- Wireless motility capsule (WMC) is a method of assessing regional (gastric emptying, small bowel transit, and colonic transit) and whole gut transit times. The sensitivity and specificity of the WMC is comparable to radiopaque marker test and scintigraphic gastric

emptying in diagnosing slow transit constipation and delayed gastric emptying, respectively. WMC is well tolerated, has good compliance, and avoids the risks of radiation exposure. However, the WMC is expensive and it is not clear that it provides added clinical value in most patients. (See 'Wireless motility capsule' above.)

- Anorectal manometry is most useful in patients with fecal incontinence and patients with constipation in whom non-mechanical causes of obstructive defecation are suspected. Anorectal manometry can also be used therapeutically as part of biofeedback retraining in patients with non-mechanical causes of obstructive defecation. (See 'Indications' above.)

REFERENCES

1. Rao SS, Camilleri M, Hasler WL, et al. Evaluation of gastrointestinal transit in clinical practice: position paper of the American and European Neurogastroenterology and Motility Societies. Neurogastroenterol Motil 2011; 23:8.
2. Baker JR, Curtin BF, Moshiree B, Rao SSC. Organizing and Developing a GI Motility Lab in Community Practice: Challenges and Rewards. Curr Gastroenterol Rep 2022; 24:73.
3. Pandolfino JE, Kahrilas PJ, American Gastroenterological Association. AGA technical review on the clinical use of esophageal manometry. Gastroenterology 2005; 128:209.
4. Kahrilas PJ, Dodds WJ, Hogan WJ, et al. Esophageal peristaltic dysfunction in peptic esophagitis. Gastroenterology 1986; 91:897.
5. Ghosh SK, Pandolfino JE, Zhang Q, et al. Quantifying esophageal peristalsis with high-resolution manometry: a study of 75 asymptomatic volunteers. Am J Physiol Gastrointest Liver Physiol 2006; 290:G988.
6. Kahrilas PJ, Sifrim D. High-resolution manometry and impedance-pH/manometry: valuable tools in clinical and investigational esophagology. Gastroenterology 2008; 135:756.
7. ASGE Technology Committee, Wang A, Pleskow DK, et al. Esophageal function testing. Gastrointest Endosc 2012; 76:231.
8. Arndorfer RC, Stef JJ, Dodds WJ, et al. Improved infusion system for intraluminal esophageal manometry. Gastroenterology 1977; 73:23.
9. Vantrappen G, Janssens J. Manometric Techniques. In: Atlas of Gastrointestinal Motility in H ealth and Disease, Schuster M (Ed), Williams and Wilkins, Baltimore 1993. p.43.
10. Yadlapati R, Kahrilas PJ, Fox MR, et al. Esophageal motility disorders on high-resolution manometry: Chicago classification version 4.0©. Neurogastroenterol Motil 2021;

33:e14058.

11. Kahrilas PJ, Bredenoord AJ, Fox M, et al. The Chicago Classification of esophageal motility disorders, v3.0. Neurogastroenterol Motil 2015; 27:160.
12. Camilleri M, Hasler WL, Parkman HP, et al. Measurement of gastrointestinal motility in the GI laboratory. Gastroenterology 1998; 115:747.
13. Braden B, Adams S, Duan LP, et al. The [13C]acetate breath test accurately reflects gastric emptying of liquids in both liquid and semisolid test meals. Gastroenterology 1995; 108:1048.
14. Ghoos YF, Maes BD, Geypens BJ, et al. Measurement of gastric emptying rate of solids by means of a carbon-labeled octanoic acid breath test. Gastroenterology 1993; 104:1640.
15. Lee JS, Camilleri M, Zinsmeister AR, et al. A valid, accurate, office based non-radioactive test for gastric emptying of solids. Gut 2000; 46:768.
16. Maes BD, Ghoos YF, Rutgeerts PJ, et al. [*C]octanoic acid breath test to measure gastric emptying rate of solids. Dig Dis Sci 1994; 39:104S.
17. Szarka LA, Camilleri M, Vella A, et al. A stable isotope breath test with a standard meal for abnormal gastric emptying of solids in the clinic and in research. Clin Gastroenterol Hepatol 2008; 6:635.
18. Keller J, Bassotti G, Clarke J, et al. Expert consensus document: Advances in the diagnosis and classification of gastric and intestinal motility disorders. Nat Rev Gastroenterol Hepatol 2018; 15:291.
19. Nullens S, Nelsen T, Camilleri M, et al. Regional colon transit in patients with dys-synergic defaecation or slow transit in patients with constipation. Gut 2012; 61:1132.
20. Metcalf AM, Phillips SF, Zinsmeister AR, et al. Simplified assessment of segmental colonic transit. Gastroenterology 1987; 92:40.
21. Grotz RL, Pemberton JH, Talley NJ, et al. Discriminant value of psychological distress, symptom profiles, and segmental colonic dysfunction in outpatients with severe idiopathic constipation. Gut 1994; 35:798.
22. Diamant NE, Kamm MA, Wald A, Whitehead WE. AGA technical review on anorectal testing techniques. Gastroenterology 1999; 116:735.
23. Camilleri M, Thorne NK, Ringel Y, et al. Wireless pH-motility capsule for colonic transit: prospective comparison with radiopaque markers in chronic constipation. Neurogastroenterol Motil 2010; 22:874.
24. Rao SS, Kuo B, McCallum RW, et al. Investigation of colonic and whole-gut transit with wireless motility capsule and radiopaque markers in constipation. Clin Gastroenterol

Hepatol 2009; 7:537.

25. Kuo B, McCallum RW, Koch KL, et al. Comparison of gastric emptying of a nondigestible capsule to a radio-labelled meal in healthy and gastroparetic subjects. Aliment Pharmacol Ther 2008; 27:186.
26. Maqbool S, Parkman HP, Friedenberg FK. Wireless capsule motility: comparison of the SmartPill GI monitoring system with scintigraphy for measuring whole gut transit. Dig Dis Sci 2009; 54:2167.
27. Kloetzer L, Chey WD, McCallum RW, et al. Motility of the antroduodenum in healthy and gastroparetics characterized by wireless motility capsule. Neurogastroenterol Motil 2010; 22:527.
28. Parkman HP, Hutson A, Sarosiek I, et al. SmartPill capsule for assessment of gastric emptying: Comparison with simultaneous gastric emptying scintigraphy (abstract). Am J Gastroenterol 2006; 101(Suppl):S99.
29. Cassilly D, Kantor S, Knight LC, et al. Gastric emptying of a non-digestible solid: assessment with simultaneous SmartPill pH and pressure capsule, antroduodenal manometry, gastric emptying scintigraphy. Neurogastroenterol Motil 2008; 20:311.
30. Zarate N, Mohammed SD, O'Shaughnessy E, et al. Accurate localization of a fall in pH within the ileocecal region: validation using a dual-scintigraphic technique. Am J Physiol Gastrointest Liver Physiol 2010; 299:G1276.
31. Agency for Healthcare Research and Quality (AHRQ). Wireless motility capsule versus other diagnostic technologies for evaluating gastroparesis and constipation: A comparative effect iveness review (No. 110). Available at: http://effectivehealthcare.ahrq.gov/ehc/products/392/1498/Constipation-gastroparesis-wireless-capsule-report-130520.pdf (Accessed on June 07, 2013).
32. Madoff RD, Williams JG, Caushaj PF. Fecal incontinence. N Engl J Med 1992; 326:1002.
33. Mitrani C, Chun A, Desautels S, Wald A. Anorectal manometric characteristics in men and women with idiopathic fecal incontinence. J Clin Gastroenterol 1998; 26:175.
34. Camilleri M, Thompson WG, Fleshman JW, Pemberton JH. Clinical management of intractable constipation. Ann Intern Med 1994; 121:520.
35. Papachrysostomou M, Smith AN. Effects of biofeedback on obstructive defecation--reconditioning of the defecation reflex? Gut 1994; 35:252.
36. Rao SS, Welcher KD, Pelsang RE. Effects of biofeedback therapy on anorectal function in obstructive defecation. Dig Dis Sci 1997; 42:2197.

37. Heymen S, Jones KR, Scarlett Y, Whitehead WE. Biofeedback treatment of constipation: a critical review. Dis Colon Rectum 2003; 46:1208.

38. Chiarioni G, Whitehead WE, Pezza V, et al. Biofeedback is superior to laxatives for normal transit constipation due to pelvic floor dyssynergia. Gastroenterology 2006; 130:657.

39. Rao SS, Seaton K, Miller M, et al. Randomized controlled trial of biofeedback, sham feedback, and standard therapy for dyssynergic defecation. Clin Gastroenterol Hepatol 2007; 5:331.

40. Heymen S, Scarlett Y, Jones K, et al. Randomized, controlled trial shows biofeedback to be superior to alternative treatments for patients with pelvic floor dyssynergia-type constipation. Dis Colon Rectum 2007; 50:428.

41. Wald A. Anorectum. In: Atlas of Gastrointestinal Motility in Health and Disease, Schuster M (Ed), Williams and Wilkins, Baltimore 1993. p.229.

42. Carrington EV, Heinrich H, Knowles CH, et al. Methods of anorectal manometry vary widely in clinical practice: Results from an international survey. Neurogastroenterol Motil 2017; 29:e13016.

43. Carrington EV, Scott SM, Bharucha A, et al. Expert consensus document: Advances in the evaluation of anorectal function. Nat Rev Gastroenterol Hepatol 2018; 15:309.

44. Lee TH, Bharucha AE. How to Perform and Interpret a High-resolution Anorectal Manometry Test. J Neurogastroenterol Motil 2016; 22:46.

45. Kim JH. How to interpret conventional anorectal manometry. J Neurogastroenterol Motil 2010; 16:437.

46. Carrington EV, Heinrich H, Knowles CH, et al. The international anorectal physiology working group (IAPWG) recommendations: Standardized testing protocol and the London classification for disorders of anorectal function. Neurogastroenterol Motil 2020; 32:e13679.

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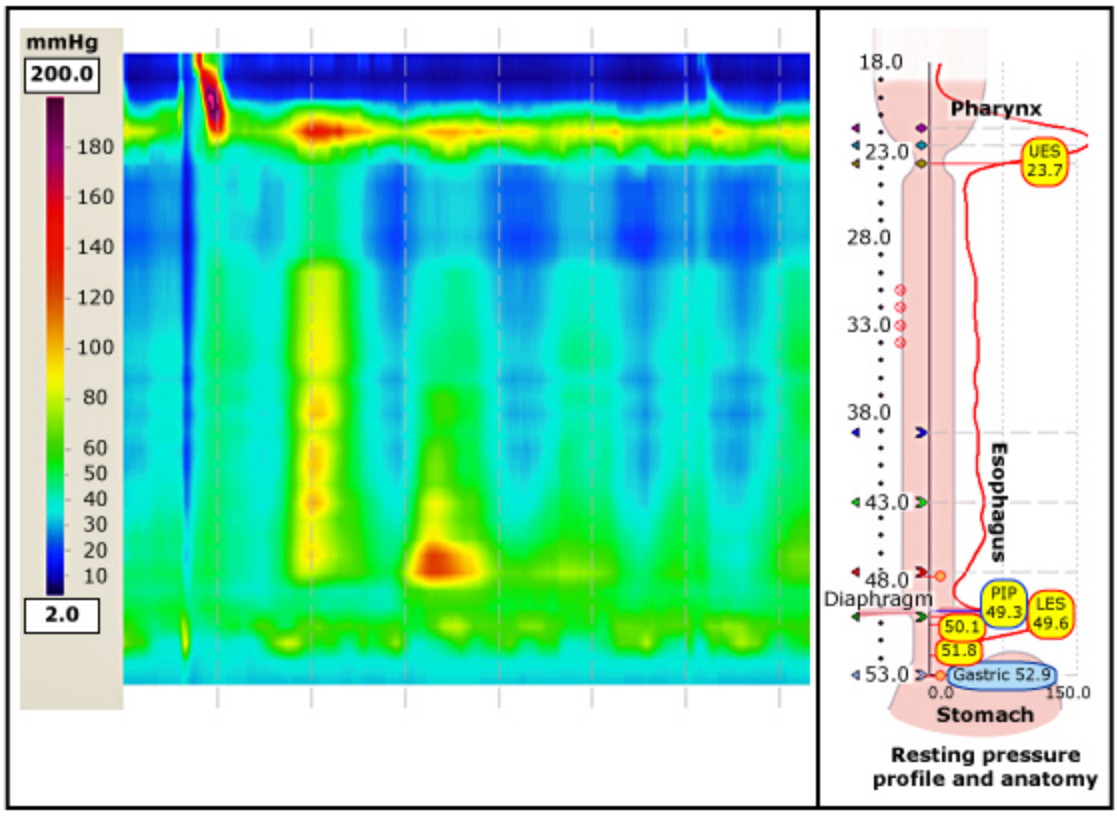
GRAPHICS

High resolution manometry



Shown is a wet swallow captured by high resolution manometry. The colors represent pressure in the esophagus as shown on the y-axis. The x-axis is time. There are simultaneous contractions in the body of the esophagus. The lower esophageal sphincter relaxes incompletely. These findings are consistent with a diagnosis of achalasia.

Courtesy of Anthony J Lembo, MD.

Graphic 77263 Version 2.0

High resolution manometry metrics and thresholds

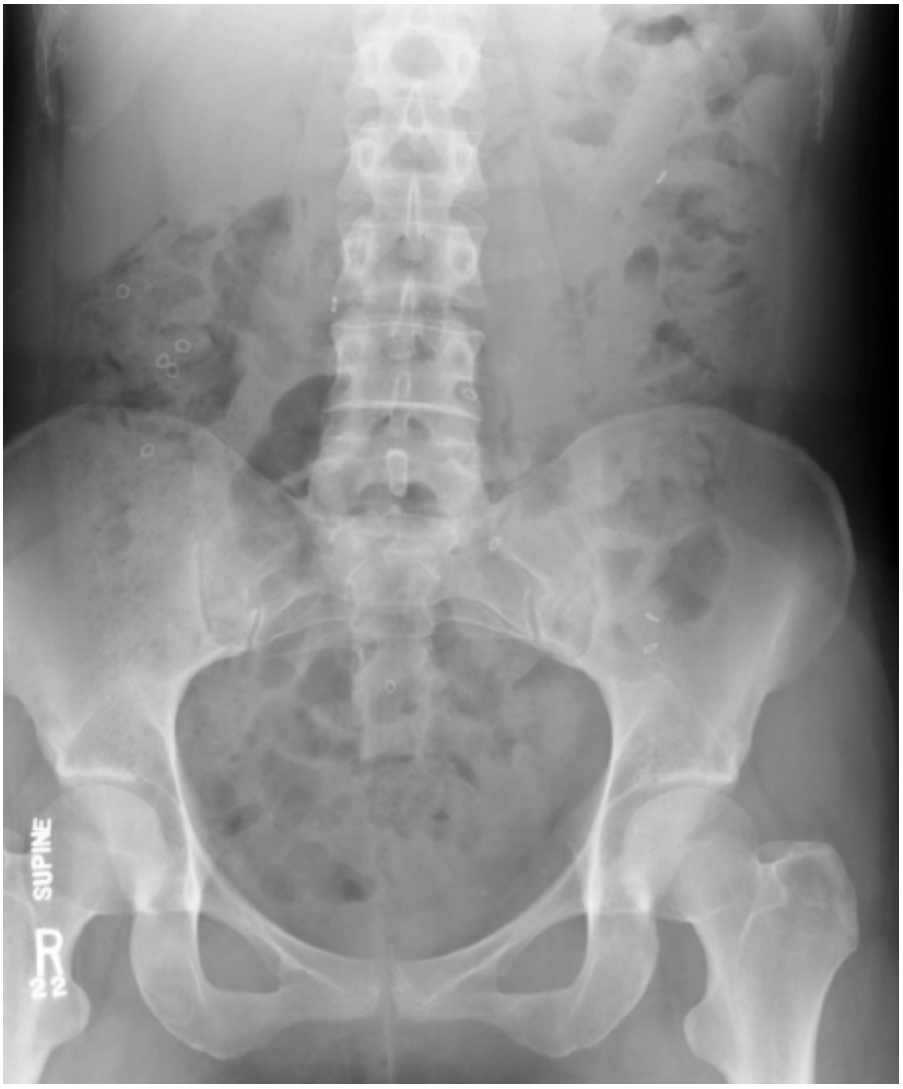
Assessment	Pressure topography metrics	Definition	Diagnostic threshold	Additional considerations
Relaxation pressure across the esophagogastric junction in response to deglutition	Integrated relaxation pressure (IRP)	Mean of the 4 s of maximal deglutitive relaxation in the 4-s window beginning at UES relaxation, contiguous or non-contiguous, referenced to gastric pressure	Abnormal deglutitive IRP relaxation: ▪ Supine median IRP ≥15 mmHg (Medtronic) ▪ Supine median IRP ≥22 mmHg (Laborie/Diversatek) ▪ Upright median IRP ≥12 mmHg (Medtronic) ▪ Upright median IRP ≥15 mmHg (Laborie/Diversatek)	IRP >12 mmHg (Medtronic) on rapid drink challenge (RDC) or IRP >25 mmHg (Medtronic) on solid test meal supports outflow obstruction
Esophageal peristalsis	Distal contractile integral (DCI) – contractile vigor	Amplitude × duration × length (mmHg•s•cm) of the distal esophageal contraction exceeding 20 mmHg from the transition zone to the proximal margin of the LES	▪ Normal contraction: DCI 450 to 8000 mmHg•s•cm ▪ Weak contraction: DCI >100 and <450 mmHg•s•cm ▪ Failed peristalsis: DCI <100 mmHg•s•cm ▪ Hypercontractile swallow: DCI >8000 mmHg•s•cm ▪ Ineffective swallow: weak contraction or failed peristalsis	Intact contractile response on multiple rapid swallow (MRS): DCI <100 mmHg•s•cm during MRS and DCI greater than single swallow mean DCI following MRS
	Contractile wavefront integrity	Contiguity of peristalsis in an isobaric contour of 20 mmHg	▪ Ineffective swallow: peristaltic break >5 cm in setting of a DCI ≥450 mmHg•s•cm	
Latency of deglutitive inhibition	Distal latency (DL)	Interval between UES	▪ Premature/spastic contraction: DL <4.5 seconds in setting of	

		relaxation and CDP	a DCI ≥450 mmHg•s•cm	
Pressurization	Isobaric contour		▪ Panesophageal pressurization: isobaric contour of ≥30 mmHg ▪ Intrabolus pressurization: isobaric contour of ≥20 mmHg in the supine position (Medtronic)	Panesophageal pressurization >20 mmHg on RDC or solid test meal supports outflow obstruction

UES: upper esophageal sphincter; LES: lower esophageal sphincter; CDP: contractile deceleration point.

Graphic 86119 Version 3.0

Radiopaque marker study

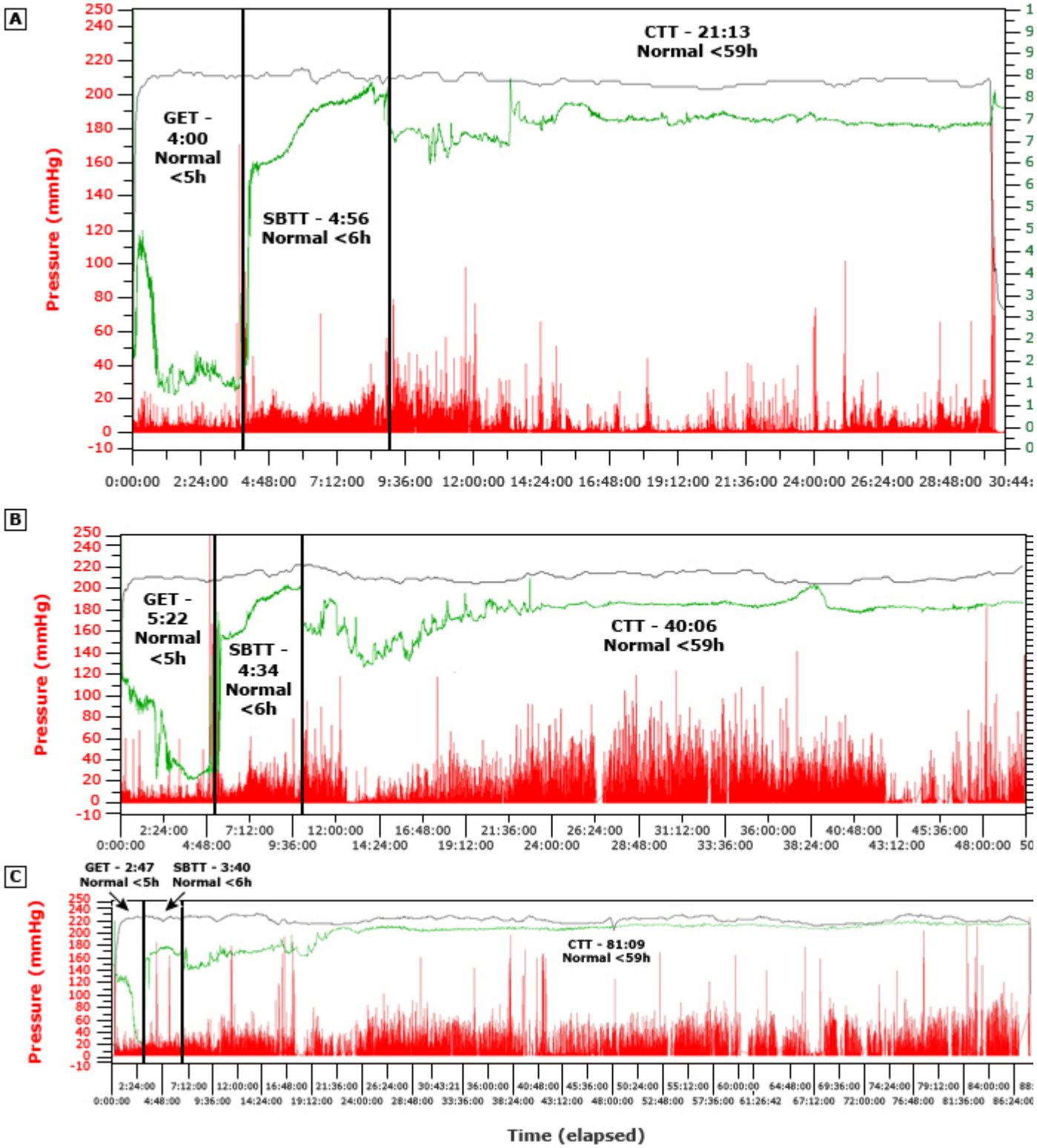


Radiopaque marker transit study showing >5 radiopaque markers on x-ray taken on day 6, indicating slow transit.

Courtesy of Satish S Rao, MD, PhD, FRCP, and Narasimha M Palagummi, MD.

Graphic 68354 Version 1.0

Wireless motility capsule studies



Representative results of wireless motility capsule studies in patients with (A) normal intestinal transit, (B) de emptying, and (C) delayed colonic transit.

GET: gastric emptying time; SBTT: small bowel transit time; CTT: colon transit time.

Courtesy of Braden Kuo, MD.

Graphic 77372 Version 2.0

Contributor Disclosures

Anthony J Lembo, MD Equity Ownership/Stock Options: Allurion [medical device for obesity]; Bristol Myers Squibb [Pharmaceuticals]; Johnson & Johnson [Pharmaceuticals]. Consultant/Advisory Boards: Aeon [Gastroparesis]; Allakos [EoE]; Ardelyx [IBS-C]; Arena [IBS]; Atmo [medical device for intestinal transit]; BioAmerica [IBS, IgG antibody food test]; Evoke [gastroparesis]; Gemelli Biotech [SIBO, IBS]; Ironwood [IBS-C, CIC, IBS-c]; orphoMed [IBS]; Pfizer [pharma]; Takeda [IBS-C, CIC]; Vibrant [CIC]. Other Financial Interest: Cin-Dome [clinical trial gastroparesis]; Vibrant - Phase III clinical trial [gastroparesis]. All of the relevant financial relationships listed have been mitigated. **Nicholas J Talley, MD, PhD** Patent Holder: Australian Provisional Patent [Diagnostic marker for functional gastrointestinal disorders]; Biomarkers of irritable bowel syndrome [Irritable bowel syndrome]; Mayo Clinic [Dysphagia questionnaire]; Mayo Clinic [Bowel Disease questionnaire]; Nepean Dyspepsia Index [Dyspepsia]; Nestec [Irritable bowel syndrome]; Singapore Provisional Patent [BDNF Tissue Repair Pathway]. Grant/Research/Clinical Trial Support: Alimetry [Gastric mapping device research collaboration]; Allakos [Gastric eosinophilic disease]; AstraZeneca [Eosinophilic gastritis, eosinophilic gastroenteritis]; Intrinsic Medicine [Bowel syndrome with constipation]; NHMRC Centre for Research Excellence in Digestive Health [NHMRC Investigator grant]. Consultant/Advisory Boards: Adelphi Values [Functional dyspepsia]; Allakos [Gastric eosinophilic disease, AK002]; AstraZeneca [Eosinophilic gastritis, eosinophilic gastroenteritis]; AusEE [Eosinophilic gut diseases]; Bayer [Inflammatory bowel syndrome]; BluMaiden [Microbiome Ad Board]; Comvita Mānuka Honey [Digestive health]; Dr Falk Pharma [Eosinophilia]; GlaxoSmithKline Australia [Educational speaker eosinophilic gut disease]; Glutagen [Celiac disease]; International Foundation for Functional Gastrointestinal Disorders [Advisory board, functional GI disorders]; Intrinsic Medicine [Human milk oligosaccharide]; IsoThrive [Esophageal microbiome]; Planet Innovation [Gas capsule, inflammatory bowel syndrome]; Progenity Inc [Intestinal capsule]; Rose Pharma [IBS]; Viscera Labs [Inflammatory bowel syndrome, diarrhea]. Other Financial Interest: Elsevier textbook royalties [Medical education]. All of the relevant financial relationships listed have been mitigated. **Shilpa Grover, MD, MPH, AGAF** No relevant financial relationship(s) with ineligible companies to disclose.

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Conflict of interest policy

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