Gastric, small bowel and colonic motility and breath-testing

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Abstract

The organs of the gastrointestinal (GI) tract are responsible for digestion, absorption and excretion of ingested food and drink. From ingestion to excretion, movement of luminal contents is regulated by the enteric and central nervous systems, which stimulate contractions of the smooth muscle of the stomach, small intestine and colon. Dysfunction of GI motility can relate to pathology of these neural complexes or changes to the smooth muscle, or appear idiopathic. When dysmotility occurs, individuals can experience a diverse array of symptoms including abdominal symptoms, change in bowel habit and serious consequences such as malnutrition and intestinal failure. One common condition associated with small intestinal dysmotility is small intestinal bacterial overgrowth (SIBO). A variety of investigations are available to assess GI motor function. These include techniques to measure accommodation, contractility and gut transit times. Investigations to assess GI motor function are diverse in terms of patient acceptability, cost, availability and level of knowledge to analyse the results. Selection of investigations therefore often depends on available resources and compliance. Assessment of SIBO can be performed using a cheap and non-invasive hydrogen–methane breath test, but marked heterogeneity exists between centres in the performance and interpretation of this technique.

Keywords Breath tests; constipation; enteric nervous system; gastrointestinal motility; intestinal pseudo-obstruction; intestine; magnetic resonance imaging; manometry; MRCP; small

Key points

- Investigations are available to assess gastric accommodation and gastric emptying function. These investigations may be utilised in patients with symptoms of dyspepsia, gastroparesis and unexplained nausea and vomiting
- Both direct measurement of contractility or a surrogate measure of transit, can be performed to assess small bowel motor function. However, there is emerging interest and research in the capabilities of dynamic magnetic resonance imaging to quantify small bowel motility
- A simple non-invasive hydrogen–methane breath test can be performed to diagnose small intestinal bacterial overgrowth or carbohydrate malabsorption in suitable patients. A UK consensus is being developed to reduce inter-centre variation in the performance and interpretation of these tests
- A range of physiological investigations are available to measure both segmental and pan-gastrointestinal motility. Selection of these tests will depend on availability, patient tolerance, safety and expertise in interpretation. These investigations should be utilised to help delineate pathophysiology and help guide treatment in order to improve outcomes

Introduction

The stomach, small intestine and colon are involved in the digestion, absorption and excretion of ingested nutrients. In patients with symptoms suspected to arise from dysfunction of these organs, motility testing and breath-testing can be used to help establish aetiology and guide management. This short review article discusses the physiology and assessment of motor function in the stomach, small intestine and colon.

Innervation of the gastrointestinal tract

The gastrointestinal (GI) tract is innervated intrinsically by the enteric nervous system, through the submucosal and myenteric plexuses. These circuits allow routine digestive mechanisms to occur without involving the central nervous system. However, extrinsic projections through sympathetic and parasympathetic efferents and visceral afferents have significant involvement in regulating motility and visceral sensation. Dysfunction at the level of the enteric and/or central nervous system can disrupt GI motor function.

The stomach

Anatomically, the stomach can be divided into four regions: the cardia, fundus, antrum and pylorus. However, motor function can be separated into two main regions:

- the proximal stomach (fundus and proximal body)
- the distal stomach (distal body, antrum and pylorus).

The function of these regions changes depending on two distinct gastric motor phases: the interdigestive and postprandial phases. During the interdigestive phase, vagally mediated tonic contractions produce heightened tone in the proximal stomach; this results in the generation of cyclical motor patterns known as migrating motor complexes (MMCs) in the distal stomach. MMCs are thought to clear the stomach of secretions and microbes during fasting.[1]

When food is ingested, the gastric motor pattern changes, with the proximal stomach relaxing to serve as a reservoir that accommodates the ingested meal. Postprandially, a tonic contraction in the proximal stomach advances the meal distally, where circular peristaltic contractions propagate from the mid-gastric body to the pylorus. The rate at which chyme passes through the pyloric sphincter to the duodenum depends on the degree of pyloric relaxation, the strength of antral contractions and duodenal resistance.

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Different methods available to the gastroenterologist for the assessment of gastric motor function

Technique	Approximate length of stay required in clinic/office	Acceptability to the patient	Radiation exposure	Physiological conditions of measurement	Standardization of test	Measurement of propagating contractions	Availability/ expense of test	Ease of interpretation of the result
Wireless motility capsule	30 minutes	High	None	Yes	Yes	No	Limited/ currently moderately expensive	Relatively easy
Gastric emptying scintigraphy	5 hours	High	Yes	Yes	No	No	Widely/ moderately expensive	Moderate
^{13}C-octanoic acid breath test	4 hours	High	No	Yes	Yes	No	Very limited/ inexpensive	Relatively easy
Antro-duodenal manometry	4 hours	Low	No	No	No	Yes	Very limited/ expensive	Difficult
Radio-opaque marker study	30 minutes (once, twice or three times depending on protocol used)	High	Yes	Yes	No	No	Widely/ inexpensive	Easy
Paracetamol absorption test	6 hours	Low	No	No	No	Yes	Cheap	Easy
Barostat insufflation	1 hour	Low	No	No	No	No	Limited	Moderate

Table 1

Assessing stomach motility

There are methods to measure both gastric accommodation and emptying function, and these are best used in combination to provide a global picture of gastric function. Table 1 provides a list of investigations suitable for assessing gastric motor function.

Clinicians may use these investigations to assess gastric function in patients with symptoms of, but not limited to, dyspepsia, gastroparesis or unexplained nausea and vomiting.

The small intestine

The small intestine controls the progression of chyme deposited from the stomach through peristaltic contractions. These mix and spread the luminal contents over the mucosal surface to ensure the effective digestion and absorption of nutrients. In the inter-digestive period, MMCs are responsible for contractions progressing distally from the duodenum down through the jejunum.

Dysmotility is often associated with either myopathic or neuropathic conditions. Dysmotility with an organic basis is of interest to the clinician as it can consequently be associated with chronic intestinal pseudo-obstruction, malnutrition, small intestinal bacterial overgrowth (SIBO) and intestinal failure. In such patients, intestinal dysmotility can be relatively easy to diagnose clinically through a knowledge of motility patterns that are characteristic of the specific disease. Cross-sectional imaging is also of great diagnostic yield in these conditions. However, in patients with chronic GI symptoms with no obvious aetiology, further investigation of small bowel motility can be appropriate to determine the underlying motor abnormalities.[2]

Assessing small bowel motility

In the clinical setting, various tools are available to assess small bowel motility. These predominantly fall into two categories:

- motility studies – direct measurement of contractility at the site of probe placement; these tests are often expensive and invasive to perform
- transit studies – surrogate measures of motor function by measuring the transit time of an intraluminal device or test meal; these are often non-invasive and cheaper to perform.

Table 2 outlines investigations suitable for the assessment of small intestinal motor function. In addition, dynamic magnetic resonance imaging is a tool of increasing interest for measuring GI function.[3]

SIBO and breath-testing

Normal microbial concentrations in the small intestine have been reported as $<10^3$ colony-forming units (CFU)/ml, with concentrations $\geq 10^3$ CFU/ml meeting the criteria for SIBO. Over-proliferation of bacteria within the small bowel can result in premature fermentation of ingested nutrients. The waste products of fermentation – gases, water and short chain fatty acids – cause changes in intraluminal conditions.

Clinical features of SIBO include bloating, abdominal pain, diarrhoea, flatulence, weight loss and nutritional deficiencies.

Different methods available to the gastroenterologist for the assessment of small intestinal motor function

Technique	Length of stay required in clinic/office	Acceptability to the patient	Radiation exposure	Physiological conditions of measurement	Standardization of test	Measurement of contractility or transit time	Availability/expense of test	Ease of interpretation of the result
Wireless motility capsule	c.30 min	High	None	Yes	Yes	Transit	Limited/currently moderately expensive	Relatively easy
Conventional small bowel manometry	c.5 h	Low	Yes (if fluoroscopy guidance employed)	No	No	Contractility	Very Limited/expensive	Difficult
High-resolution manometry	c.5 h	Low	Yes (if fluoroscopy guidance employed)	No	No	Contractility	Very Limited/expensive	Difficult
Lactulose hydrogen breath test	c.4 h	High	No	Yes	Yes	Transit	Widely/inexpensive	Easy
Small bowel scintigraphy study	c.6 h	High	Yes	Yes	No	Transit	Limited/moderately expensive	Moderate
Endoluminal image analysis	c.30 min	High	None	Yes	Yes	Contractility	Limited/moderately expensive	Moderate to difficult
Dynamic magnetic resonance imaging	1 h	Moderate	None	Yes	No	Both	Limited/predominately research tool	Difficult

Table 2

Small intestinal dysmotility is a risk factor for the development of SIBO because the stagnation of luminal contents provides favourable conditions for an overproliferation of bacteria.

The gold standard test for diagnosis of SIBO is a bacterial count derived from a jejunal aspirate, but this is highly invasive and expensive to perform. A non-invasive hydrogen–methane breath test (HMBT) is therefore commonly used in clinical practice to diagnose SIBO. HMBTs can also be used in the diagnosis of carbohydrate malabsorption. However, there is marked variation between centres in the performance and interpretation of tests. A North American consensus was recently published produced to help standardize HMBTs, and similar efforts are currently being undertaken in the UK.[4]

Colonic motility

In contrast to the stomach and small intestine, the colon does not have a cyclical motor pattern of MMCs. Three distinct colonic contraction patterns have been identified, each with differing spatiotemporal patterns:

- **Segmental contractions** and **low-amplitude propagated contractions** (<50 mmHg) occur frequently and cause a slow propulsion of contents towards the rectum, allowing for mixing and absorption of water.

Summary of conditions associated intestinal dysmotility

	Condition/disorder
Primary disorders	Visceral myopathy Primary dysautonomia Visceral neuropathy
Functional disorders	Irritable bowel syndrome Chronic idiopathic constipation
Immune-mediated, collagen diseases, genetic degenerative and metabolic disease	Diabetes mellitus Systemic sclerosis Muscular dystrophy Myotonic dystrophy Crohn's disease Ulcerative colitis Hypothyroidism
Disease of central or enteric nervous system	Parkinson's disease Multiple sclerosis Hirschsprung's disease Spinal cord injury Stroke
Iatrogenic	Pharmacological – opiates, antidepressants, antipsychotics Surgical – postoperative ileus, bariatric surgery, gastrointestinal surgery Radiation enteritis
Other	Diverticulosis Chagas' disease Small intestinal bacterial overgrowth

Table 3

- **Giant migrating contractions** (>100 mmHg) produce mass movement of contents, occur infrequently and are thought to be associated with urge to defaecate.

Assessment of colonic motility

High-resolution manometry with closely spaced sensors is proving a valuable tool in establishing colonic motor patterns. Close spacing of pressure sensors compared with traditional manometry has allowed the direction of contractile propagation to be identified, with retrograde contractions occurring in the colon. This technique is predominately a research tool as the only data reported have been from 34 healthy adults.[5]

The wireless motility capsule (WMC) SmartPill® allows entry into the caecum to be identified using changes in pH and pressure readings. When the WMC is excreted from the body, a drop in temperature occurs and colonic transit time can be calculated using these two time points. Whereas WMC assessment takes only 30 minutes in the clinician's office, scintigraphy, although an accurate measure of colonic transit, is time-consuming and costly to perform. Colonic transit can most simply be assessed using a plain film abdominal X-ray at a fixed time point after ingestion of radio-opaque markers. This method has been shown to be highly reproducible and can help to identify whether constipation symptoms are related to delayed colonic transit. Marker studies do, however, expose patients to moderate doses of ionizing radiation. There is good agreement between all three methods in the measure of total transit time.

Table 3 provides a summary of conditions associated with small intestinal and colonic dysmotility. ◆

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TEST YOURSELF

To test your knowledge based on the article you have just read, please complete the questions below. The answers can be found at the end of the issue or online here.

Question 1

A 46-year-old man presented with a 3-week history of abdominal pain, bloating and diarrhoea after meals. He had previously been found to have systemic sclerosis.

Investigations

- Small bowel manometry demonstrated a myopathic pattern of dysmotility, with low-amplitude contractions
- Serum vitamin B_{12} 100 ng/litre (160–760)

Which physiological investigation would be most appropriate to offer the patient next?

A. Barostat insufflation
B. Hydrogen–methane breath-testing
C. Radio-opaque marker study
D. Small bowel manometry
E. Wireless motility capsule

Question 2

A 51-year-old woman presented with a 6-month history of nausea, early satiety, vomiting and abdominal pain. The additional medical history included diabetes mellitus with known peripheral sensory neuropathy and poor glycaemic control. The patient's GP had referred her to the local district general hospital's gastroenterology department for an upper gastrointestinal endoscopy. Despite an overnight fast, the endoscopy revealed marked food residue in the stomach.

What is the most likely cause of the patient's symptoms?

A. Functional dyspepsia
B. Hirschsprung's disease
C. Intestinal pseudo-obstruction
D. Irritable bowel syndrome
E. Gastroparesis

Question 3

A 34-year-old woman presented with a 5-year history of constipation and abdominal discomfort and dyspepsia. She was taking 30 mg of sodium picosulphate once daily and reported opening her bowels once a week with this regimen. Investigations had demonstrated no organic pathology that could be causing her symptoms. Her gastroenterologist wanted to assess the patient's small intestinal and colonic motility but did not want to expose her to ionising radiation.

What investigation(s) might be most appropriate to assess this?

A. High-resolution small and large bowel manometry studies
B. Scintigraphy studies
C. Wireless motility capsule
D. Radio-opaque marker study
E. Dynamic magnetic resonance imaging (MRI) studies