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A national consensus guideline on the performance and interpretation of hydrogen- and methane-based breath tests for carbohydrate malabsorption, small intestinal bacterial overgrowth, and intestinal methanogen overgrowth

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Abstract

Abdominal bloating, distension, excessive gas, abdominal pain, diarrhea and constipation are common symptoms that may arise from carbohydrate malabsorption, carbohydrate intolerance, small intestinal bacterial overgrowth (SIBO), intestinal methanogen overgrowth (IMO), or disorders of gut–brain interaction. Hydrogen- and methane-based breath tests are safe, noninvasive, inexpensive and widely used, but differences in indications, patient preparation, test performance and interpretation can lead to inconsistent diagnoses and management. At the recommendation of the Israeli Gastroenterology Association, a multidisciplinary panel of adult and pediatric gastroenterologists, neurogastroenterologists, dietitians, clinical nutrition specialists and heads of gastrointestinal laboratories reviewed the literature and reached consensus during 8 meetings. This guideline provides practical standards for breath testing in adults and children. The panel recommends simultaneous measurement of hydrogen and methane, structured symptom recording during testing, standardized pretest preparation, and cautious interpretation in settings that alter anatomy or orocecal transit time. Lactulose is recommended as the preferred substrate for SIBO/IMO testing, with glucose as an acceptable alternative. Carbohydrate malabsorption should be distinguished from intolerance by the presence or absence of typical symptoms during the test. The guideline also defines suspected hypersensitivity and highlights methane production as a cause of false-negative hydrogen-based carbohydrate tests. These recommendations are intended to harmonize breath test practice and reporting, and to support rational, test-directed treatment in adult and pediatric patients.

Keywords Breath test, small intestinal bacterial overgrowth, intestinal methanogen overgrowth, carbohydrate malabsorption, carbohydrate intolerance

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Introduction

Abdominal bloating, abdominal distension, excessive gas, abdominal pain, and altered bowel habits are common reasons for referral to gastroenterology clinics. These symptoms are nonspecific, and may reflect disorders of gut–brain interaction, carbohydrate malabsorption or intolerance, small intestinal bacterial overgrowth (SIBO), intestinal methanogen overgrowth (IMO), motility disorders, altered gastrointestinal anatomy, pancreatic exocrine insufficiency, celiac disease, inflammatory bowel disease, or other conditions.

Hydrogen and methane are produced by microbial metabolism in the intestinal lumen and are not generated by human cells. After production in the gut, these gases are absorbed into the bloodstream and exhaled [1,2]. This physiologic principle supports the use of breath testing as an indirect measure of carbohydrate fermentation and microbial overgrowth [2-4]. In carbohydrate malabsorption, unabsorbed sugars reach the colon and are fermented by bacteria and methanogens. In SIBO or IMO, a significant early rise in hydrogen or methane may occur because fermentation takes place in the small intestine [2,3,5].

Methanogens are archaea rather than bacteria. Methanobrevibacter smithii is the predominant methanogen identified in many methane-positive patients [6]. The term IMO is increasingly preferred when methane production is the key abnormality, because methanogens can inhabit both the small and large intestine [5,7]. Methane production is clinically relevant because methane is associated with constipation and slower intestinal transit, and because conversion of hydrogen to methane can reduce hydrogen concentrations and thereby produce false-negative hydrogen-only tests [5,6,8,9].

Although breath tests are safe, simple, and widely available, their diagnostic performance is imperfect [3,10,11]. Test results are influenced by patient preparation, recent medications, antimicrobial exposure, substrate choice, baseline gas concentrations, sampling interval, reporting of symptoms, and orocecal transit time [2-4,11]. A rapid transit time can mimic an early rise after lactulose and therefore create a false-positive interpretation for SIBO [12-16], whereas methane production and altered anatomy can reduce sensitivity in other settings [8,17,18]. The absence of uniform local standards has resulted in inconsistencies among centers that perform breath testing.

The aim of this consensus guideline is to provide practical, standardized recommendations for indications, patient preparation, performance, interpretation and reporting of hydrogen- and methane-based breath tests in adult and pediatric patients with suspected SIBO, IMO, or carbohydrate malabsorption/intolerance.

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Scope and target users

This document addresses breath testing for SIBO, IMO, and malabsorption or intolerance of lactose, fructose, sorbitol, and related fermentable carbohydrates. The recommendations are intended for gastroenterologists, pediatric gastroenterologists, neurogastroenterologists, dietitians, laboratory directors, technicians, and referring physicians who request or interpret breath tests.

This document does not replace clinical judgment. Results should be interpreted in the context of the individual patient, including pretest probability, alarm features, previous gastrointestinal surgery, medication exposure, underlying motility disorders, and alternative diagnoses.

Consensus development process

At the recommendation of the Israeli Gastroenterology Association, a panel was convened that included experts in adult and pediatric neurogastroenterology, clinical nutrition and dietetics, and directors of gastroenterology laboratories. The panel members had extensive experience in performing and interpreting breath tests, and in managing patients with suspected SIBO, IMO and carbohydrate intolerance.

Eight multidisciplinary meetings were held between February 2021 and February 2023. Before each meeting, the relevant literature and international guidance were reviewed. The panel discussed 5 core domains: indications for breath testing; pretest preparation and patient instructions; technical performance of breath tests; structured symptom questionnaires before and during testing; and interpretation and reporting of test results. Final statements were based on available evidence, international guidance, and expert consensus when evidence was limited.

Indications for breath testing

The panel supports breath testing in 4 main clinical scenarios (Table 1).

Direct diagnosis of SIBO by duodenal or jejunal aspirate culture or sequencing is invasive, expensive, susceptible to contamination, and rarely used in routine practice [2,10]. Breath testing is therefore the most practical diagnostic tool in most clinical settings [2,3,5,7]. Because symptoms overlap substantially with irritable bowel syndrome and other disorders of gut–brain interaction, objective testing can support clinical decision-making and improve physician-patient communication.

For suspected carbohydrate intolerance, 2 approaches are commonly used: supervised empirical dietary elimination or objective breath testing. The panel recognizes both approaches. However, when the response to dietary elimination is incomplete, ambiguous or difficult to interpret, objective testing is preferred. When SIBO is suspected, a dedicated SIBO/IMO breath test should generally precede carbohydrate

Table 1 Indications for breath testing

Indication	Clinical purpose
Diagnosis of SIBO	Noninvasive assessment when symptoms and risk factors suggest excessive microbial fermentation in the small bowel
Assessment after SIBO/IMO therapy	Evaluation of persistent symptoms after treatment, to distinguish persistent overgrowth from other causes of symptoms
Evaluation of excessive methane production	Assessment of methane-associated constipation or prolonged intestinal transit, including patients with constipation-predominant irritable bowel syndrome
Diagnosis of carbohydrate malabsorption/ intolerance	Objective evaluation of lactose, fructose, sorbitol, and related carbohydrate maldigestion when symptoms, diet history, or clinical uncertainty justify testing

SIBO, small intestinal bacterial overgrowth; IMO, intestinal methanogen overgrowth

testing, because SIBO can cause false-positive carbohydrate breath tests [19,20].

Patient preparation

Pretest preparation is essential, because recent antibiotics, probiotics, prebiotics, laxatives, prokinetics, bowel cleansing, diet, smoking, oral bacterial fermentation and exercise can alter baseline gas concentrations or transit time [2-4,11]. The goal is to minimize avoidable false-positive and false-negative results and to reduce test cancellations due to high baseline hydrogen.

Recommendations for patient preparation are summarized in Table 2.

Technical performance of breath tests

Breath testing requires serial measurement of exhaled hydrogen and methane before and after ingestion of a test substrate. Results should be interpreted by the change from baseline, with attention to the timing of the rise and the symptoms reported during the test [2,3]. The panel recommends that laboratories use devices that measure hydrogen and methane simultaneously [2,3,5]. This approach improves the ability to identify IMO and methane producers, and reduces false-negative interpretation of hydrogen-only tests [8].

Symptoms should be recorded at baseline and at fixed intervals during the test [3,20]. Typical symptoms include bloating, distension, excessive gas, abdominal pain, diarrhea, constipation, and postprandial fullness. The report should indicate whether symptoms occurred during the test and whether they were typical of the patient's usual complaints. Recommended substrates, sampling duration and pediatric doses are summarized in Table 3.

Table 2 Patient preparation before breath testing

Preparation item	Recommendation
Antibiotics, probiotics, and prebiotics	Avoid for 4 weeks before the test when clinically feasible
Bowel cleansing	Avoid colonoscopy, capsule endoscopy preparation, or any bowel cleansing procedure for 4 weeks before the test
Prokinetics and laxatives	Avoid for at least 1 week before the test when clinically feasible
Diet	Consume only allowed low-fermentation foods during the 24 h before testing; provide written instructions to patients
Fasting	Fast completely for approximately 12 h before testing. Water is allowed until 2 h before the test and may be used for regular medications
Smoking	Avoid smoking from the evening before the test and throughout the test
Physical activity	Avoid strenuous activity for approximately 12 h before testing
Oral hygiene	Brush teeth on the morning of the test and rinse the mouth with mouthwash before baseline sampling
Regular medication	Do not routinely stop regular medications, including proton pump inhibitors, unless the referring physician gives a specific instruction
Previous gastrointestinal surgery	Individualize substrate choice and interpretation in patients after stoma creation, colectomy, bariatric surgery, bowel resection, or bypass anatomy

Choice of substrate for SIBO/IMO testing

Lactulose and glucose each have advantages and limitations. Lactulose is not absorbed in the small bowel and can detect fermentation along a larger length of intestine; however, early colonic arrival due to rapid orocecal transit may create false-positive results [3,12-16]. Glucose is absorbed in the proximal small bowel and may be more specific, but it may miss distal overgrowth because the substrate is absorbed before reaching the affected segment [3,10].

After considering these advantages and limitations, the panel recommends lactulose as the preferred substrate for SIBO/IMO testing, with glucose as an acceptable alternative. The report should state which substrate was used and should interpret positive results in light of pretest probability and potential transit confounding [3].

Baseline gas concentrations

A low baseline hydrogen concentration is desirable. High baseline hydrogen may reflect inadequate preparation, recent

Table 3 Technical performance of breath tests and pediatric dosing

Test	Adult substrate and duration	Pediatric dose for children >6 years
SIBO/IMO: lactulose	Lactulose is the preferred substrate. Collect baseline samples and serial samples for at least 90-120 min; a 180-min protocol may assist in visualizing colonic fermentation	No separate pediatric lactulose dose was endorsed by the panel; use local pediatric protocol and clinical judgment
SIBO/IMO: glucose	Glucose is an acceptable alternative, especially when specificity is prioritized. The panel recognizes that glucose may miss distal SIBO	2 g/kg body weight up to 50 g, dissolved in water
Lactose malabsorption/ intolerance	Lactose breath test with serial sampling for 180 min	2 g/kg body weight up to 25 g, dissolved in water
Fructose malabsorption/ intolerance	Fructose breath test with serial sampling for 180 min	0.5 g/kg body weight up to 25 g, dissolved in water
Sorbitol malabsorption/ intolerance	Sorbitol breath test with serial sampling for 180 min	0.2 g/kg body weight up to 12.5 g, dissolved in water

SIBO, small intestinal bacterial overgrowth; IMO, intestinal methanogen overgrowth

intake of fermentable carbohydrates, oral fermentation, or SIBO. The panel recommends attempting to lower an elevated baseline by asking the patient to rinse the mouth and drink water, followed by repeat baseline sampling. When baseline values remain above the recommended threshold, test cancellation and rescheduling should be considered. The approach to baseline gas concentrations is included in Table 4.

Interpretation of breath test results

The report should include baseline hydrogen and methane concentrations, gas concentrations over time, the maximal delta from baseline, the timing of the rise, symptoms during the test, substrate used, test duration, and any factor that limits interpretation [2,3]. Borderline or discordant results should be interpreted cautiously, rather than reported as unequivocally normal or abnormal. Interpretation and reporting standards are summarized in Table 4.

Table 4 Baseline gas concentrations and interpretation of breath test results

Situation or diagnostic category	Recommended approach, consensus definition or reporting standard
Baseline gas concentrations	
Carbohydrate test: baseline hydrogen <15 ppm	Proceed with testing
SIBO/IMO test: baseline hydrogen <10 ppm	Proceed with testing
Borderline baseline hydrogen	Repeat baseline sampling after water and mouthwash; consider rescheduling with stricter preparation if still elevated
Persistently elevated baseline hydrogen on 2 separate properly prepared tests	SIBO is likely but not definitively proven; consider treatment or further evaluation according to clinical context
High baseline methane	A methane concentration ≥10 ppm at baseline or any time point supports methane-producer status/IMO, depending on clinical context and substrate protocol
Interpretation and reporting categories	
SIBO	Increase in hydrogen >20 ppm above baseline within 90 min after lactulose or glucose ingestion
IMO/excessive methane production	Methane ≥10 ppm at baseline or at any time point during testing. In a SIBO/IMO protocol, an early methane rise >10 ppm above baseline within 90 min also supports abnormal methanogen activity
SIBO ruled out	No significant hydrogen rise and no methane abnormality within 90 min; interpret with caution if pretest probability is high or anatomy/transit is altered
Borderline SIBO result	Hydrogen rise of 15-20 ppm within 90 min, particularly in a symptomatic patient, cannot confidently exclude SIBO
Carbohydrate malabsorption	Hydrogen rise >20 ppm above baseline between 90 and 180 min without typical symptoms during the test
Carbohydrate intolerance	Hydrogen rise >20 ppm above baseline between 90 and 180 min with typical symptoms during the test
Possible SIBO during carbohydrate testing	Hydrogen rise >20 ppm before 90 min during a carbohydrate test; perform a dedicated SIBO/IMO breath test rather than relying on the carbohydrate test alone
Suspected hypersensitivity	Typical symptoms during a carbohydrate test with hydrogen rise <15 ppm and no diagnostic methane abnormality; evaluate disorders of gut–brain interaction and other causes
Possible false-negative carbohydrate test	Negative hydrogen response in a methane producer, because methanogens may consume hydrogen and reduce the hydrogen delta

SIBO, small intestinal bacterial overgrowth; IMO, intestinal methanogen overgrowth

Special clinical situations

Breath testing after gastrointestinal surgery requires individualized interpretation [17,18,21]. After total colectomy, lactulose breath testing may support SIBO if there is a significant hydrogen rise, but carbohydrate intolerance tests are usually

non-diagnostic, because normal colonic fermentation is absent, or transit is substantially altered. After bariatric surgery, bowel resection, stoma creation or bypass procedures, both false-positive and false-negative results may occur, because substrate delivery and transit differ from standard anatomy.

In these patients, the test request should state the clinical question, the relevant anatomy and the substrate selected. If SIBO is confirmed after surgery involving blind loops or altered access, systemic antibiotics may be more appropriate than poorly absorbed agents, depending on anatomy and clinical judgment.

Management implications

The panel considers SIBO/IMO a treatable microbial overgrowth syndrome when the diagnosis is supported by symptoms and breath testing. Treatment aims to reduce microbial overgrowth and improve bloating, abdominal pain, diarrhea, constipation, or related symptoms. Because symptoms are nonspecific, empirical antibiotics without testing are discouraged in most patients. Test-directed therapy also reduces unnecessary antibiotic exposure and supports reassessment when symptoms persist.

Rifaximin is the best-studied antibiotic for SIBO and has a favorable safety profile because it is minimally absorbed [22]. Alternative antibiotics with published evidence include ciprofloxacin, metronidazole, amoxicillin-clavulanate, tetracycline, norfloxacin, trimethoprim-sulfamethoxazole and doxycycline [23-28]. In methane-positive constipation or IMO, neomycin alone, or in combination with rifaximin, has been associated with reduction of methane concentrations in small studies [29,30]. The choice of antibiotic should account for local availability, contraindications, previous exposure, suspected anatomy and antimicrobial stewardship. Management implications are summarized in Table 5 and a treatment algorithm for patients with suspected SIBO/IMO is presented in Fig. 1.

Table 5 Management implications according to breath test results and clinical response

Clinical scenario	Suggested management
Positive SIBO/IMO test with typical symptoms	Treat with an appropriate antibiotic regimen; reassess symptoms after treatment
Persistent symptoms after treatment	Repeat SIBO/IMO breath testing. If still positive, consider retreatment and evaluate adherence, anatomy, motility, and risk factors
Symptoms persist but repeat SIBO/IMO test is negative	Evaluate carbohydrate intolerance, dietary triggers, disorders of gut–brain interaction, celiac disease, inflammatory bowel disease, pancreatic insufficiency, and other causes
Symptom improvement followed by early relapse	Consider retreatment in symptomatic patients, especially when the initial response was clear and relapse occurred within several weeks
Carbohydrate intolerance confirmed	Institute targeted dietary intervention with a dietitian, avoiding unnecessary broad dietary restriction when a specific trigger is identified
Suspected hypersensitivity	Consider disorders of gut–brain interaction and refer to clinicians experienced in neurogastroenterology and dietetics

SIBO, small intestinal bacterial overgrowth; IMO, intestinal methanogen overgrowth

Non-antibiotic approaches

Evidence supporting probiotics, prebiotics, gluten-free diet, low-FODMAP diet, or fecal microbiota transplantation for eradication of SIBO is limited. These interventions may have roles in symptom management for selected patients, but the panel does not recommend them as primary eradication therapy for SIBO/IMO.

Discussion

This consensus guideline addresses a practical problem in daily gastroenterology: breath tests are widely used, but inconsistent protocols and terminology can lead to inconsistent diagnoses. The panel emphasizes 3 principles. First, hydrogen and methane should be measured together whenever possible. Second, symptoms during the test must be recorded and incorporated into the interpretation, especially for carbohydrate intolerance. Third, breath test interpretation requires a clinical context, particularly in patients with rapid transit, constipation, altered anatomy or a high pretest probability of SIBO.

A key terminology issue is the distinction between carbohydrate malabsorption and carbohydrate intolerance. Malabsorption describes an abnormal gas response without typical symptoms during the test, whereas intolerance requires both an abnormal gas response and symptoms during the test. This distinction is clinically important, because it avoids attributing chronic symptoms to a carbohydrate merely because the carbohydrate is malabsorbed. Conversely, symptom reproduction with a normal gas response suggests suspected hypersensitivity, or another disorder of gut–brain interaction, rather than classic malabsorption.

The principal controversy in SIBO testing remains the role of orocecal transit time [12-16]. Lactulose breath testing may detect early colonic arrival rather than small bowel fermentation in some patients. However, lactulose also has practical advantages, and may be more sensitive for distal overgrowth [3,10]. The panel therefore recommends lactulose as the preferred local standard, while explicitly acknowledging the need to interpret results according to pretest probability and transit-related limitations. Glucose remains an acceptable alternative, particularly when specificity is prioritized.

The recommendations in this document have already influenced local practice by encouraging the transition from hydrogen-only testing to combined hydrogen and methane

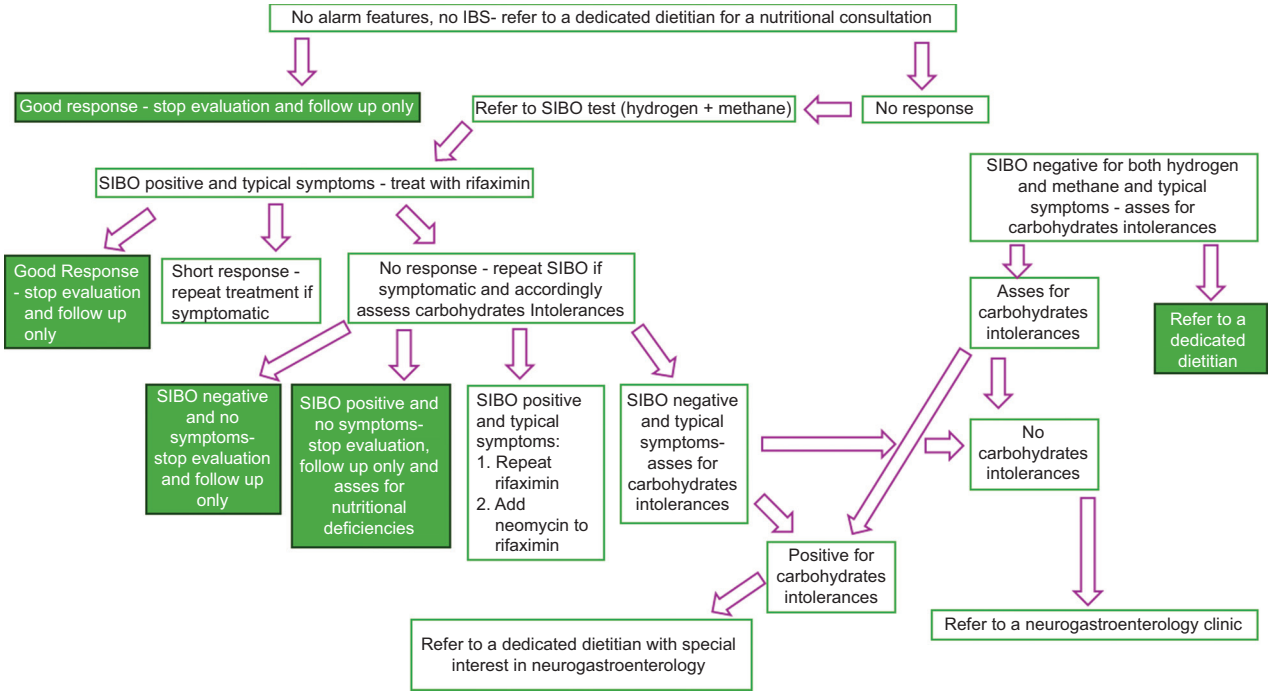

Figure 1 Treatment algorithm for a patient with suspected SIBO/IMO and typical symptoms. The algorithm emphasizes dietary assessment when alarm features are absent, dedicated SIBO/IMO breath testing when symptoms persist, test-directed antibiotic treatment, repeat testing when symptoms do not respond, and evaluation for carbohydrate intolerance or disorders of gut–brain interaction when SIBO/IMO is excluded or successfully treated

SIBO, small intestinal bacterial overgrowth; IMO, intestinal methanogen overgrowth; IBS, irritable bowel syndrome

measurement. This change is expected to improve the detection of methane producers and reduce false-negative reports in patients whose microbial ecosystem converts hydrogen to methane.

The evidence base for several breath test practices remains limited, and no breath test perfectly distinguishes SIBO from rapid transit in all patients. Some recommendations therefore rely on expert consensus in addition to published data. In addition, these recommendations were developed for practical use in clinical laboratories and may require local adaptation according to available devices, substrates and patient populations.

In conclusion, this national consensus guideline provides standardized indications, preparation instructions, performance standards, interpretation criteria and management implications for hydrogen- and methane-based breath testing in adults and children. Standardization should improve diagnostic consistency, distinguish carbohydrate malabsorption from intolerance, identify methane producers and IMO, and support rational test-directed management of patients with suspected SIBO/IMO and carbohydrate intolerance.

References

1. Levitt MD. Volume and composition of human intestinal gas determined by means of an intestinal washout technique. *N Engl J Med* 1971;**284**:1394-1398.
2. Rezaie A, Buresi M, Lembo A, et al. Hydrogen and methane-based breath testing in gastrointestinal disorders: the North American consensus. *Am J Gastroenterol* 2017;**112**:775-784.
3. Hammer HF, Fox MR, Keller J, et al; European H2-CH4-breath test group. European guideline on indications, performance, and clinical impact of hydrogen and methane breath tests in adult and pediatric patients: European Association for Gastroenterology, Endoscopy and Nutrition, European Society of Neurogastroenterology and Motility, and European Society for Paediatric Gastroenterology Hepatology and Nutrition consensus. *United European Gastroenterol J* 2022;**10**:15-40.
4. Gasbarrini A, Corazza GR, Gasbarrini G, et al; 1st Rome H2-Breath Testing Consensus Conference Working Group. Methodology and indications of H2-breath testing in gastrointestinal diseases: the Rome Consensus Conference. *Aliment Pharmacol Ther* 2009;**29**(Suppl 1):1-49.
5. Pimentel M, Saad RJ, Long MD, Rao SSC. ACG clinical guideline: small intestinal bacterial overgrowth. *Am J Gastroenterol* 2020;**115**:165-178.
6. Kim G, Deepinder F, Morales W, et al. *Methanobrevibacter smithii* is the predominant methanogen in patients with constipation-predominant IBS and methane on breath. *Dig Dis Sci* 2012;**57**:3213-3218.
7. Quigley EMM, Murray JA, Pimentel M. AGA clinical practice update on small intestinal bacterial overgrowth: expert review. *Gastroenterology* 2020;**159**:1526-1532.
8. Gottlieb K, Le C, Wacher V, et al. Selection of a cut-off for high- and low-methane producers using a spot-methane breath test: results from a large north American dataset of hydrogen, methane and carbon dioxide measurements in breath. *Gastroenterol Rep (Oxf)* 2017;**5**:193-199.

9. Pimentel M, Lin HC, Enayati P, et al. Methane, a gas produced by enteric bacteria, slows intestinal transit and augments small intestinal contractile activity. *Am J Physiol Gastrointest Liver Physiol* 2006;**290**:G1089-G1095.
10. Khoshini R, Dai SC, Lezcano S, Pimentel M. A systematic review of diagnostic tests for small intestinal bacterial overgrowth. *Dig Dis Sci* 2008;**53**:1443-1454.
11. Saad RJ, Chey WD. Breath testing for small intestinal bacterial overgrowth: maximizing test accuracy. *Clin Gastroenterol Hepatol* 2014;**12**:1964-1972.
12. Ford AC, Spiegel BM, Talley NJ, Moayyedi P. Small intestinal bacterial overgrowth in irritable bowel syndrome: systematic review and meta-analysis. *Clin Gastroenterol Hepatol* 2009;**7**:1279-1286.
13. Zhao J, Zheng X, Chu H, et al. A study of the methodological and clinical validity of the combined lactulose hydrogen breath test with scintigraphic oro-cecal transit test for diagnosing small intestinal bacterial overgrowth in IBS patients. *Neurogastroenterol Motil* 2014;**26**:794-802.
14. Yu D, Cheeseman F, Vanner S. Combined oro-caecal scintigraphy and lactulose hydrogen breath testing demonstrate that breath testing detects oro-caecal transit, not small intestinal bacterial overgrowth in patients with IBS. *Gut* 2011;**60**:334-340.
15. Lin EC, Massey BT. Scintigraphy demonstrates high rate of false-positive results from glucose breath tests for small bowel bacterial overgrowth. *Clin Gastroenterol Hepatol* 2016;**14**:203-208.
16. Connolly L, Chang L. Combined orocecal scintigraphy and lactulose hydrogen breath testing demonstrate that breath testing detects orocecal transit, not small intestinal bacterial overgrowth in patients with irritable bowel syndrome. *Gastroenterology* 2011;**141**:1118-1121.
17. Rao SSC, Tan G, Abdulla H, et al. Does colectomy predispose to small intestinal bacterial and fungal overgrowth? *Clin Transl Gastroenterol* 2018;**9**:146.
18. Sabate JM, Coupaye M, Ledoux S, et al. Consequences of small intestinal bacterial overgrowth in obese patients before and after bariatric surgery. *Obes Surg* 2017;**27**:599-605.
19. Nucera G, Gabrielli M, Lupascu A, et al. Abnormal breath tests to lactose, fructose and sorbitol in irritable bowel syndrome may be explained by small intestinal bacterial overgrowth. *Aliment Pharmacol Ther* 2005;**21**:1391-1395.
20. Amieva-Balmori M, Coss-Adame E, Rao NS, Dávalos-Pantoja BM, Rao SSC. Diagnostic utility of carbohydrate breath tests for SIBO, fructose, and lactose intolerance. *Dig Dis Sci* 2020;**65**:1405-1413.
21. Petrone P, Sarkisyan G, Fernández M, et al. Small intestinal bacterial overgrowth in patients with lower gastrointestinal symptoms and a history of previous abdominal surgery. *Arch Surg* 2011;**146**:444-447.
22. Gatta L, Scarpignato C. Systematic review with meta-analysis: rifaximin is effective and safe for the treatment of small intestine bacterial overgrowth. *Aliment Pharmacol Ther* 2017;**45**:604-616.
23. Sajjad A, Mottershead M, Syn WK, Jones R, Smith S, Nwokolo CU. Ciprofloxacin suppresses bacterial overgrowth, increases fasting insulin but does not correct low acylated ghrelin concentration in non-alcoholic steatohepatitis. *Aliment Pharmacol Ther* 2005;**22**:291-299.
24. Tahan S, Melli LC, Mello CS, Rodrigues MS, Bezerra Filho H, de Morais MB. Effectiveness of trimethoprim-sulfamethoxazole and metronidazole in the treatment of small intestinal bacterial overgrowth in children living in a slum. *J Pediatr Gastroenterol Nutr* 2013;**57**:316-318.
25. Attar A, Flourié B, Rambaud JC, Franchisseur C, Ruszniewski P, Bouhnik Y. Antibiotic efficacy in small intestinal bacterial overgrowth-related chronic diarrhea: a crossover, randomized trial. *Gastroenterology* 1999;**117**:794-797.
26. Shindo K, Machida M, Fukumura M, Koide K, Yamazaki R. Omeprazole induces altered bile acid metabolism. *Gut* 1998;**42**:266-271.
27. Ghoshal UC, Srivastava D, Misra A, Ghoshal U. A proof-of-concept study showing antibiotics to be more effective in irritable bowel syndrome with than without small-intestinal bacterial overgrowth: a randomized, double-blind, placebo-controlled trial. *Eur J Gastroenterol Hepatol* 2016;**28**:281-289.
28. Lewis SJ, Potts LF, Malhotra R, Mountford R. Small bowel bacterial overgrowth in subjects living in residential care homes. *Age Ageing* 1999;**28**:181-185.
29. Pimentel M, Chow EJ, Lin HC. Normalization of lactulose breath testing correlates with symptom improvement in irritable bowel syndrome. A double-blind, randomized, placebo-controlled study. *Am J Gastroenterol* 2003;**98**:412-419.
30. Low K, Hwang L, Hua J, Zhu A, Morales W, Pimentel M. A combination of rifaximin and neomycin is most effective in treating irritable bowel syndrome patients with methane on lactulose breath test. *J Clin Gastroenterol* 2010;**44**:547-550.