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Original Article

Unclear Abdominal Discomfort: Pivotal Role of Carbohydrate Malabsorption

Miriam Goebel-Stengel,[1]* Andreas Stengel,[2] Marco Schmidtmann,[1] Ivo van der Voort,[1] Peter Kobelt[2] and Hubert Mönnikes[1]

[1]Department of Internal Medicine, Institute of Neurogastroenterology and Motility, Martin-Luther Hospital, Academic Teaching Institution of Charité - University Medical Center, Berlin, Germany; and [2]Charité Center for Internal Medicine and Dermatology, Division of General Internal and Psychosomatic Medicine; Charité-Universitätsmedizin Berlin, Campus Benjamin Franklin, Berlin, Germany

Background/Aims
Carbohydrate malabsorption is frequent in patients with functional gastrointestinal disorders and in healthy volunteers and can cause gastrointestinal symptoms mimicking irritable bowel syndrome (IBS). The aim of this study was to investigate the prevalence of symptomatic lactose and fructose malabsorption in a large population of patients with IBS-like symptoms based on Rome II criteria.

Methods
Patients with unclear abdominal discomfort (n = 2,390) underwent lactose (50 g) and fructose (50 g) hydrogen (H_2) breath tests and depending on the results further testing with 25 g fructose or 50 g glucose, or upper endoscopy with duodenal biopsies. Additionally, this population was investigated regarding the prevalence of small intestinal bacterial overgrowth (SIBO) based on glucose breath test and celiac disease.

Results
Of the 2,390 patients with IBS-like symptoms, 848 (35%) were symptomatic lactose malabsorbers and 1,531 (64%) symptomatic fructose malabsorbers. A combined symptomatic carbohydrate malabsorption was found in 587 (25%) patients. Severe fructose malabsorbers (pathologic 25 g fructose test) exhaled significantly higher H_2 concentrations in the 50 g test than patients with negative 25 g fructose test ($P < 0.001$). Out of 460/659 patients with early significant H_2 increase in the lactose and fructose test who underwent a glucose breath test, 88 patients had positive results indicative of SIBO and they were significantly older than patients with negative test result ($P < 0.01$). Celiac disease was found in 1/161 patients by upper endoscopy.

Conclusions
Carbohydrate malabsorption is a frequent but underestimated condition in patients with IBS-like symptoms although diagnosis can be easily confirmed by H_2 breath testing.
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Key Words
Breath tests; Fructose; Hydrogen; Irritable bowel syndrome; Lactose

*Correspondence: Miriam Goebel-Stengel, MD, PhD
Department of Internal Medicine, Institute of Neurogastroenterology and Motility, Martin-Luther Krankenhaus,
Caspar-Theyβ-Str. 27-31, 14193 Berlin, Germany.
Tel: +49-30-8955-3111, Fax: +49-30-8955-4554, E-mail: miriam.goebel-stengel@gmx.de

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228

Introduction

Recurrent or chronic abdominal discomfort is a common condition in the health care setting. Most patients have had prior medical evaluation that did not yield a satisfactory diagnosis. Common organic causes of chronic abdominal pain and discomfort encompass peptic ulcer disease, postoperative adhesive bands or gynaecologic disorders. However, the irritable bowel syndrome (IBS) and carbohydrate malabsorption are also frequent in patients with unexplained gastrointestinal symptoms.

Lactose, a disaccharide composed of galactose and glucose, is cleaved into absorbable monosaccharides by the enzyme lactase which is found in the epithelium of the small intestine. Lactose intolerance results from a lack of lactase often referred to as lactase deficiency.[1] The non-digested lactose cannot be absorbed in the small intestine and thus reaches the colon. For the monosaccharide fructose, the glucose transporter (GLUT)-5 protein of the enterocytes is the preferred transport system out of the small intestinal lumen.[2] A lack of this transporter and/or a shortened small intestinal transit time result in an exceeding transport capacity for fructose.[3,4]

At their onward transport, fructose and lactose that remain in the lumen of the small intestine subsequently reach the colon and are fermented by resident bacteria.[5-7] Degradation products of the bacterial metabolism are hydrogen (H_2), carbon dioxide, hydrogen sulfide, methane and short chain fatty acids.[5,6,8] While hydrogen is partly absorbed and exhaled and does not lead to osmotic diarrhea which is caused by short chain fatty acids and undigested oligodisaccharides,[5-7] it may, similar to other gaseous metabolites, cause bloating and abdominal distension resulting in abdominal discomfort and cramps, especially in individuals with visceral hypersensitivity. Altogether, these symptoms can imitate IBS.[9,10]

Hydrogen breath tests offer an excellent non-invasive method to detect excessive production of hydrogen as seen in fructose and lactose malabsorption. The disability to sufficiently cleave lactose accompanied by clinical symptoms is referred to as symptomatic lactose malabsorption while the lack of clinical symptoms is referred to as lactose malabsorption. After infancy, most mammals, including humans, lose the intestinal enzyme lactase and thus the ability to digest lactose.[11] Due to a genetic mutation, others keep the ability and worldwide, the persistence of the lactase gene is the most common enzymatic variant. Interestingly, this highly penetrant autosomal-dominant genetic polymorphism obeys a characteristic geographic distribution increasing from North to South, which is underlined by data showing that in Scandinavian countries only 3-8% of the population lack lactase,[12] while the prevalence in the Austrian study group is around 20%,[13] in China about 28%,[14] in the Mediterranean up to 70% and in equatorial Africa even up to 98%.[15] One has to consider that due to migration the number of people experiencing nutritional problems due to lactase deficiency in Europe steadily increases.

Lactose malabsorption has already been well recognized as a cause of non-specific gastrointestinal (GI) symptoms.[16-18] On the contrary, malabsorption of fructose is less well studied but has recently received growing attention through the fact that restricting rapidly fermentable oligo-, di- and monosaccharides and polyols (FODMAPs) is beneficial in controlling symptoms of abdominal discomfort.[19,20] Indeed, 2 studies reported a prevalence of fructose malabsorption in functional dyspepsia or unexplained GI symptoms of 40-55% and 73%, respectively.[10,18] Therefore, it seems to be reasonable to perform routine fructose H_2 breath tests in patients with unexplained abdominal symptoms who have had an unremarkable medical check-up including laboratory tests, physical examination, ultrasound and endoscopy and in the absence of "red flags" (e.g., unintended weight loss, rectal bleeding, fever, severe diarrhea or vomiting, persistent pain in the upper or lower right abdomen, family history of inflammatory bowel disease or colon cancer).

The gold standard to detect small intestinal bacterial overgrowth (SIBO) is the culture of jejunal aspirates. However, in clinical practice the H_2 breath test with glucose is often preferred.[4] In healthy subjects, glucose is completely absorbed in the proximal small intestine, while in SIBO glucose is fermented by bacteria before absorption resulting in an early or late rise of H_2 levels from the dysbiosis of the jejunum or ileum, respectively.

Up to now there is a lack of studies describing the role of carbohydrate malabsorption in patients with IBS-like symptoms in large study populations. Therefore, in a retrospective analysis, we characterized 2,390 patients with unclear abdominal discomfort with regards to occurrence, prevalence and severity of carbohydrate malabsorption, SIBO and celiac disease which may also lead to abdominal discomfort and IBS-like symptoms.

Materials and Methods

Patient Population Characteristics

The documentation and archive system of the gastroenterological unit of the Charité Medical Center has been used as

study entry database. Patients were outpatients or admitted from other departments of the Charité Medical Center for hydrogen breath testing due to their GI symptoms in the years from 2000 to 2006. All patients consented to their data analysis for study purpose. They were asked about GI infections, antibiotics use or colonoscopy within the last 4-6 weeks. The breath tests were only performed 4-6 weeks after such an event. All subjects who presented with unclear abdominal discomfort (e.g., IBS-like symptoms) had unremarkable physical examination, lab results, ultrasound and endoscopy in the absence of "red flags" (e.g., unintended weight loss, rectal bleeding, fever, family history of inflammatory bowel disease and colon cancer, persistent pain in the upper or lower right abdomen, severe diarrhea or vomiting). All subjects who had taken 2 H_2 breath tests, with 50 g lactose and fructose, respectively, were included (n = 2,390).

Abdominal IBS-like symptoms were assessed once at the first contact with patient by a GI symptom questionnaire that is routinely used by the outpatient clinic at the Charité Medical Center for functional GI and motility disorders. This questionnaire has not been validated yet but was used before[21] and can group patients according to Rome II criteria.

Hydrogen Breath Test

The H_2 breath tests all followed the same regimen. After an 18-hour overnight fast (water only), an end-expiratory breath sample was collected from the patients into a syringe. The breath sample was immediately analyzed by the use of a GMI Exhaled Hydrogen Monitor (GMI Medical, Renfrew, UK; measurement range 0-250 parts per million [ppm], sensitivity 2 ppm, measurement accuracy $\pm 2\%$, ± 1 ppm for values < 50 ppm) and the result of the measurement was documented. First, 2 baseline values for H_2 were determined in the end-expiratory exhalation air. Only patients who showed a starting value of ≤ 20 ppm were included. After an oral load of the relevant carbohydrate in 200 mL water, according to the current German guidelines,[4] further breath samples were obtained every 10 minutes over the measurement period of 180 minutes. An increase of the end-expiratory H_2 concentration > 20 ppm above average baseline within 180 minutes was defined as significant/pathologic rise. The time until the first significantly increased value, time and value of the maximum H_2 concentration as well as the concurrent abdominal symptoms under the carbohydrate load were documented.

Definitions and Measurements

Lactose hydrogen breath test

Patients received a solution consisting of 50 g lactose in 200 mL water. An H_2 increase without typical abdominal symptoms was defined as lactose malabsorption. Patients with a pathologic H_2 increase in combination with abdominal symptoms were defined as symptomatic lactose malabsorbers.

Fructose hydrogen breath test

The German guideline on clinically relevant breath tests in gastroenterology recommends the performance of hydrogen breath tests with 50 g fructose (in 200 mL water) first and an additional test with 25 g fructose (in 100 mL water) in case of a positive result to rule out fructose malabsorption.[4] The term fructose intolerance describes a genetic disorder (deficiency of aldolase B due to ALDOB gene mutation). Analogous to lactose indigestion, we use the term fructose malabsorption to describe intestinal fructose malabsorption expressed by an H_2 increase without corresponding symptoms and symptomatic fructose malabsorption for patients who present with symptoms in addition to their malabsorption. Patients with a pathologic H_2 breath test with 50 g fructose and a normal H_2 breath test with 25 g fructose are defined as moderate symptomatic fructose malabsorbers, whereas patients showing pathologic results in both H_2 breath tests are classified as severe symptomatic fructose malabsorbers.

Glucose hydrogen breath test

An early pathologic increase in hydrogen levels (≥ 20 ppm above baseline during the first 60 minutes of the measurement period) in both lactose and fructose breath tests is suggestive of SIBO. Patients with suspected SIBO underwent the additional breath test with 50 g of glucose in 200 mL water.

Upper endoscopy

Patients with positive fructose and lactose breath tests are suggestive for celiac disease that often presents with secondary carbohydrate malabsorption due to duodenal atrophy. Therefore, these patients were asked to undergo upper endoscopy with duodenal biopsies.

Statistical Methods

Data are expressed as mean $\pm$ SEM and analyzed by ANOVA followed by all pair-wise multiple comparison procedures (Tukey's

post hoc test); $P < 0.05$ was considered significant.

Results

Study Population

Overall, 2,390 patients with unclear abdominal discomfort performed both H_2 breath tests with 50 g lactose and with 50 g fructose. Of these, 1,548 were female and 806 were male. The mean age was 49.6 years. The majority of patients was Caucasian (n = 2,132), followed by Arabians (n = 128), Mediterraneans (n = 116), Asians (n = 12) and Africans (n = 1).

Prevalence of Carbohydrate Malabsorption

In the H_2 breath test with 50 g lactose, 1,023/2,390 patients showed a significant H_2 increase corresponding to a prevalence of lactose malabsorption of 42.8%. Of these, 848 patients additionally reported abdominal symptoms, indicating a prevalence of lactose intolerance of 35.5% of the whole study population. Of these, 554 were female and 294 were male. Additionally, 365 patients reported symptoms although no H_2 increase was seen, while in contrast, 175 patients showed an H_2 increase but reported no symptoms (Table 1). Of the 848 symptomatic lactose malabsorbers, 679 (80.1%) were of Caucasian, 93 (11.0%) of Arabic, 65 (7.7%) of Mediterranean and 11 (1.3%) of Asian origin. The one African reported symptoms but did not have a corresponding H_2 increase. On the contrary, the prevalence of symptomatic lactose malabsorption according to ethnicity was 91.7% in the Asian population, 72.7% in the Arabian, 56% in the Mediterranean, and

Table 1. Prevalence of Symptomatic Lactose and Fructose Malabsorption

Breath test		Lactose (50 g)	Fructose (50 g)	Fructose (25 g)
Performed		2,390	2,390	552
Abdominal symptoms	overall	1,213	1,703	267
	without H_2 increase	365	172	97
	with H_2 increase	848	1,531	170
H_2 increase	overall	1,023	1,818	226
	without abdominal symptoms	175	287	56

H_2, hydrogen.
Data are presented as number of patients.

31.8% in the Caucasian population, respectively.

In the breath test with 50 g fructose 1,818/2,390 patients had a significant H_2 increase, which translates into a prevalence of fructose malabsorption of 76.1%. Of these, 1,531 patients were symptomatic fructose malabsorbers and reported abdominal symptoms indicating a prevalence of moderate symptomatic fructose malabsorption of 64% of the whole study population. Another 172 patients reported abdominal symptoms but had no H_2 increase, while in contrast, 287 patients showed an H_2 increase but reported no symptoms (Table 1). Of the 1,531 symptomatic fructose malabsorbers, 1,367 were of Caucasian, 82 of Arabic, 74 of Mediterranean, 7 of Asian and 1 of African origin.

The prevalence of symptomatic fructose malabsorption according to ethnicity was 64.1% in the Arabian and Caucasian, 63.8% in the Mediterranean and 58.3% in the Asian population, respectively.

Of all patients, 829 subjects showed a significant increase in both H_2 breath tests. Of those, 587 additionally reported symptoms corresponding to a prevalence of combined symptomatic carbohydrate malabsorption of 25% of the whole study population.

Severity of Symptomatic Fructose Malabsorption

To assess the severity of fructose malabsorption, in case of a pathologic H_2 breath test with 50 g fructose (n = 1,818) an additional H_2 breath test with 25 g fructose was conducted (Table 1). This breath test was performed in 552 patients. Of these, 226 patients had a significant H_2 increase. Of these, 170 patients reported abdominal symptoms, thus defined as severe symptomatic fructose malabsorbers. Abdominal symptoms without H_2 increase were reported by another 97 patients, while in contrast, 56 patients showed an H_2 increase but reported no symptoms.

Correlation of Maximal H_2 Increase and Severity of Fructose Malabsorption

The comparison of maximal H_2 concentrations in the H_2 breath test with 50 g fructose showed that patients with pathologic H_2 breath test with 25 g fructose, classified as severe fructose malabsorbers, exhaled significantly higher H_2 concentrations than patients with negative H_2 breath test with 25 g fructose, defined as moderate fructose malabsorbers (123.6 $\pm$ 4.9 vs. 90.1 $\pm$ 2.9 ppm, $P < 0.001$).

Small Intestinal Bacterial Overgrowth

In 460/659 patients with early H_2 increase in the fructose and

Table 2. H_2 Breath Test for Small Intestinal Bacterial Overgrowth (Glucose)

Glucose (50 g)	
Performed (N)	460
Abdominal symptoms overall	123
Abdominal symptoms without H_2 increase	44
Abdominal symptoms with H_2 increase	61
H_2 increase overall	88
H_2 increase without abdominal symptoms	17
No H_2 increase, no abdominal symptoms	277
Early H_2 increase (SIBO)	85
Late H_2 increase (Dysbiosis of the terminal ileum)	3

Patients with early significant hydrogen (H_2) increase in the fructose and lactose test (n = 659) were asked to take the glucose breath test to exclude small intestinal bacterial overgrowth (SIBO).
Data are presented as number of patients.

lactose breath test, a H_2 breath test with 50 g glucose was performed (Table 2). A significant H_2 increase, indicative of bacterial overgrowth was detected in 88 patients. A total of 123 patients indicated abdominal symptoms. In this subgroup 44 patients did not show a significant H_2 increase, whereas 61 patients had a significant H_2 increase. Of all 88 patients with significant H_2 increase, 85 showed an early H_2 increase, which is indicative of SIBO. Three patients had a late increase indicative of terminal ileum dysbiosis. The comparison of age between patients with positive and negative glucose breath test indicated that patients with positive glucose breath test were significantly older than patients with negative test (54.8 ± 1.8 vs. 49.4 ± 0.8 years, $P < 0.01$).

Prevalence of Other Gastrointestinal Pathologies

Of all combined carbohydrate malabsorbers (n = 829), 161 patients underwent upper endoscopy with duodenal biopsies. Of these, one was identified to have celiac disease and one had a duodenal ulcer. Neither gastric ulcer nor Whipple's disease were detected.

Discussion

In patients of mainly Caucasian origin with unclear abdominal discomfort the prevalence of symptomatic lactose and fructose malabsorption was 35% and 64%, respectively. A combined lactose and fructose carbohydrate malabsorption was found in 25%. To our knowledge, this study investigates for the first time the prevalence of carbohydrate malabsorption in such a large collec-

tive of patients with IBS-like symptoms. The prevalence of symptomatic fructose malabsorption was similar ($\sim$60%) in the different ethnic groups while lactose malabsorption is differentially distributed throughout the different ethnic groups (Asian > Arabian > Mediterranean > Caucasian).

Böhmer and Tuynman[22] found 24% of IBS patients to be lactose malabsorbers and Hamm et al[23] diagnosed 23% lactose malabsorbers in a collective of 1,122 IBS patients. Hamm et al[23] estimated 25% of the European and United States population to suffer from lactase deficiency. In our study 1,023/2,390 patients (43%) had increase in H_2 levels after the lactose breath test and were thus referred to as lactose malabsorbers. Of these, 848 additionally experienced abdominal symptoms during the test and were thus symptomatic lactose malabsorbers corresponding to a prevalence of 35% in our patient collective. It can be stated that we observed a higher prevalence of symptomatic lactose malabsorption than reported before in the literature. We thus assume that lactose indigestion is a frequent condition in patients with IBS-like symptoms. A heterogeneous patient collective consisting of ethnic groups with higher prevalence of lactose malabsorption (e.g., African or Mediterranean origin) could explain these findings but our patient collective consisted predominantly of Caucasians and 80% of the symptomatic lactose malabsorbers were of Caucasian origin. The prevalence of symptomatic lactose malabsorption according to ethnicity followed a characteristic distribution pattern and showed the highest prevalence in Asians, followed by Arabians, Mediterraneans and Caucasians. However, our patient collective was comprised of 2 times more females than males, and 65% of the symptomatic lactose malabsorbers were female which is consistent with other studies.[24,25] Supported by the study of Erminia et al[25] who reported a higher prevalence of symptomatic lactose malabsorption in women than men, the question remains whether and why more females suffer from lactose indigestion.

Farup et al[26] examined a collective of IBS patients and healthy volunteers in Norway and found in both groups an approximate percentage of 4% to suffer from lactose malabsorption. Interestingly, about 6-fold more patients experienced symptoms during or after the lactose breath test,[26] although no H_2 increase was seen. In our study 365/2,390 (15%) patients complained of symptoms during or after the test without H_2 increase. The 3-hour lactose test duration was essentially based on the study by Casellas and Malagelada[27] who showed that the lactose test could be shortened to 3 hours without loss of sensitivity and specificity, when a high dose of lactose is used. However, there is a chance of false

negativity and symptomatic patients without H_2 increase within 3 hours could have prolonged the test time to reveal a later H_2 increase. Furthermore, parallel methane analysis has been reported to enhance sensitivity of breath tests and reduce the rate of false negative results,[28,29] but was not performed in our study.

Since 1978, when elimination of fructose was first shown to relieve symptoms in patients suffering from abdominal discomfort,[30] the role of fructose malabsorption in the genesis of IBS-like symptoms has received more attention. In a retrospective analysis of patients with IBS and fructose malabsorption on a low-fructose/fructan diet,[31] 74% of patients reported symptomatic improvement on this dietary regimen. In a follow-up, randomized, placebo-controlled rechallenge trial in patients with IBS with fructose malabsorption[32] all patients improved on a low-fructose/fructan diet, with significant exacerbation of symptoms by rechallenge of fructose or fructans. Since the 1970's the consumption of fructose has risen 1,000-fold and has approached levels at which malabsorption is even seen in healthy adults in which incomplete absorption of free fructose induces IBS-like symptoms that are often less severe and less frequent.[33] In line with this finding, Beyer et al[34] showed that 50% of healthy subjects suffered from gastrointestinal symptoms after a fructose load of 25 g. Furthermore, sorbitol-containing food products have increased in popularity and sorbitol is often used in lower calorie foods and sugar-free chewing gum since it does not require insulin for metabolism and has fewer calories than glucose. Yet, fructose is one of sorbitol's metabolic by-products. Heavy consumers of diet products or fructose-sweetened beverages may consume between 60 g and 100 g fructose daily.[35] A large serving size of common popular carbonated non-alcoholic beverages (700 mL) contains as much as 43 g of fructose. Therefore, it is quite common that one consumes more than 25 g of fructose with one meal and testing patients with 50 g fructose is thus not an unrealistic load. However, some might consider such a dose too high with the rational that every person develops abdominal symptoms at this dose but it has to be taken into account that fructose doses of less than 50 g show false negative results in part of the patients with fructose malabsorption.[10] In addition, 19-29% of test persons do neither develop symptoms nor produce excessive hydrogen upon ingestion of 50 g fructose since all studies that used 50 g fructose reported a prevalence of fructose malabsorption of 71-81%.[10,35-39] In our collective of 2,390 patients with IBS-like symptoms, 17% did neither develop symptoms nor have an increase in H_2 levels after a 50 g fructose load which corroborates former findings of smaller patient collectives. However,

64% suffered from symptomatic fructose malabsorption. The present study is in line with former results by Choi et al[10] who observed 73% fructose malabsorption in patients (n = 183, 50 g/150 mL water, fructose concentration of 33%) with unexplained abdominal symptoms. Moreover, a prevalence of 44% for fructose malabsorption and 73% for fructose-sorbitol malabsorption was described in a collective of patients with unclear functional complaints or diagnosed with IBS.[40] Both, test dose and concentration seem to be important for the hydrogen increase. Choi et al[10] found an increasing prevalence of fructose malabsorption of 39%, 70% and 80% with test concentrations of 10%, 20% and 30% (with 50 g fructose each), respectively. In our study we used 50 g/200 mL and 25 g/100 mL which correspond to a fructose concentration of 25% in both tests. Thus, the fact that we found a higher prevalence of fructose malabsorption with 50 g compared to 25 g is not a result of the concentration (25% in both) but rather the test dose.

In our study, patients that were symptomatic moderate fructose malabsorbers with a 50 g load (n = 1,531) were asked to undergo a fructose breath test with 25 g of fructose (n = 557). Of these, 170 responded positively and were thus referred to as severe symptomatic fructose malabsorbers. Interestingly, patients that were severe fructose malabsorbers showed higher end-expiratory hydrogen levels with the 50 g load compared to the moderate fructose malabsorbers. Whether these patients would thus benefit more from a stricter dietary approach remains to be investigated.

The term "intolerance" may be misleading. In our study we use the term malabsorption instead. The positive result of a breath test alone does not render a person intolerant to the respective sugar. In clinical routine, patients with a positive breath test should undergo elimination diet to determine the relevance of the breath test result in daily life. Only if symptoms disappear during a lactose or fructose free diet they could be considered as being intolerant. However, some patients have negative test results but suffer from gastrointestinal symptoms every time they consume lactose containing food products. This group should be considered intolerant as well-even without test. Taken together, not just test results but food diaries and outcome of an elimination diet define food intolerance.

SIBO is characterized by abnormally high bacterial population levels in the small intestine. IBS-like symptoms such as pain, bloating or diarrhea can be found in SIBO. Due to the non-invasiveness, low costs and good sensitivity compared to jejunal culture, breath tests are becoming more popular[41,42] in the diagnosis of SIBO. In our study 88/460 subjects had a positive

glucose breath test indicative of SIBO. Furthermore, we confirmed a correlation of SIBO with age which has been extensively described before.[43,44] Malnutrition in the elderly has been discussed as a cause for malabsorption making the bowel more susceptible for bacterial overgrowth.[43,45] Furthermore, hypochlorhydria, impaired peristalsis, duodenal diverticula and previous gastrointestinal surgery have been mentioned as possible causes for intestinal malabsorption.[43] In the present retrospective trial, our patient collective was not evaluated concerning these co-morbidities.

Recently, other studies detected that SIBO is a frequent condition in therapy refractory patients with celiac disease[46-48] rendering a glucose breath test in celiac patients helpful. Pironti et al[24] concluded in their study that routine duodenal biopsies could be helpful in revealing abnormalities in patients with chronic diarrhea and/or abdominal pain. In our patient collective, 161 patients with combined carbohydrate malabsorption underwent upper endoscopy with duodenal biopsies. However, only one patient with celiac disease was detected indicating that it very rarely underlies the combined carbohydrate malabsorption.

According to a recent meta-analysis, the current IBS prevalence is 11% worldwide[49] and management of the disease is challenging. It is noteworthy that patients suffering from carbohydrate malabsorption can present with IBS-like symptoms and are often misdiagnosed with IBS. Thus, it is worth to exclude well-treatable conditions such as symptomatic carbohydrate malabsorption before confronting patients with the diagnosis of IBS. Although current German, British and American guidelines discuss a role for carbohydrate malabsorption in IBS, they do not specifically recommend both, fructose and lactose breath tests prior to the diagnosis.[50-52] Since most patients with carbohydrate malabsorption benefit from an elimination diet, this condition can be easily treated.

In conclusion, in our collective of 2,390 patients with unexplained gastrointestinal symptoms with otherwise unremarkable clinical findings and in the absence of red flag signs, roughly one third were symptomatic lactose malabsorbers and two thirds symptomatic fructose malabsorbers, respectively. One quarter of patients had a combined symptomatic carbohydrate malabsorption. Thus, given the high prevalence of carbohydrate malabsorption in patients with unexplained gastrointestinal discomfort or pain, H_2 breath tests to detect lactose and/or fructose malabsorption are recommended in the diagnostic workup of these patients.

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