Carbohydrate Malabsorption and the Effect of Dietary Restriction on Symptoms of Irritable Bowel Syndrome and Functional Bowel Complaints

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Key words: carbohydrate malabsorption, sugar malabsorption, lactose, sorbitol, fructose, dietary restriction, irritable bowel syndrome, functional bowel complaints

Abstract

Background: Carbohydrate malabsorption of lactose, fructose and sorbitol has already been described in normal volunteers and in patients with functional bowel complaints including irritable bowel syndrome. Elimination of the offending sugar(s) should result in clinical improvement.

Objective: To examine the importance of carbohydrate malabsorption in outpatients previously diagnosed as having functional bowel disorders, and to estimate the degree of clinical improvement following dietary restriction of the malabsorbed sugar(s).

Methods: A cohort of 239 patients defined as functional bowel complaints was divided into a group of 94 patients who met the Rome criteria for irritable bowel syndrome and a second group of 145 patients who did not fulfill these criteria and were defined as functional complaints. Lactose (18 g), fructose (25 g) and a mixture of fructose (25 g) plus sorbitol (5 g) solutions were administered at weekly intervals. End-expiratory hydrogen and methane breath samples were collected at 30 minute intervals for 4 hours. Incomplete absorption was defined as an increment in breath hydrogen of at least 20 ppm, or its equivalent in methane of at least 5 ppm. All patients received a diet without the offending sugar(s) for one month.

Results: Only 7% of patients with IBS and 8% of patients with FC absorbed all three sugars normally. The frequency of isolated lactose malabsorption was 16% and 12% respectively. The association of lactose and fructose-sorbitol malabsorption occurred in 61% of both patient groups. The frequency of sugar malabsorption among patients in both groups was 78% for lactose malabsorption (IBS 82%, FC 75%), 44% for fructose malabsorption and 73% for fructose-sorbitol malabsorption (IBS 70%, FC 75%). A marked improvement occurred in 56% of IBS and 60% of FC patients following dietary restriction. The number of symptoms decreased significantly in both groups ($P<0.01$) and correlated with the improvement index (IBS $P<0.05$, FC $P<0.025$).

Conclusions: Combined sugar malabsorption patterns are common in functional bowel disorders and may contribute to symptomatology in most patients. Dietary restriction of the offending sugar(s) should be implemented before the institution of drug therapy.

IMAJ 2000;2:583–587

IBS = irritable bowel syndrome
FC = functional complaints

The Rome criteria [1] are currently in use to define irritable bowel syndrome. Functional bowel complaints may exist in many patients not fulfilling these criteria. An organic disease is generally excluded by a battery of tests which include complete blood count, erythrocyte sedimentation rate, serum iron, thyroid-stimulating hormone, liver enzymes, urine sediment, stool tests for occult blood, ova and parasites, an endoscopic work-up (esophagogastroduodenoscopy and sigmoidoscopy or colonoscopy), and an abdominal and pelvic ultrasonography. While many centers perform the hydrogen breath test to diagnose lactose malabsorption, not many physicians realize that isolated lactose malabsorption is uncommon and that it is generally combined with fructose and sorbitol malabsorption. These malabsorption patterns are frequently overlooked as part of the process of exclusion of a treatable organic cause.

Carbohydrate malabsorption of lactose, fructose and sorbitol has already been described in normal volunteers and in patients with functional bowel complaints including the irritable bowel syndrome [2–7]. Some studies suggest that sugar malabsorption is not the etiologic cause for functional complaints but rather a trigger mechanism for symptoms in a predisposed group of patients who suffer from gut hyperalgesia.

Gut hyperalgesia described in the irritable bowel syndrome [8] is probably the underlying sensitizing condition, while sugar malabsorption may trigger symptoms via mechanisms of gaseous distension and rapid transit. Production of short chain fatty acids by bacterial fermentation of the malabsorbed sugar may also be involved in increased ileal and colonic motor activity [9,10]. Once a specific malabsorption pattern is identified, elimination of the offending sugar(s) should result in clinical improvement. In a study of 25 patients with functional bowel disorders, 40% improved after restriction of the offending sugar [5].

The aim of our study was to examine the importance of carbohydrate malabsorption in outpatients previously diagnosed with functional bowel disorders, and to estimate the degree of clinical improvement following dietary restriction of the malabsorbed sugar(s).

Materials and Methods

A total of 239 patients presented to our outpatient gastroenterology clinic for the management of functional gastrointestinal complaints of at least 3 months duration. Patients had a normal physical examination including gynecologic or prostate digital examination. Complete blood count, erythrocyte sedimentation rate, serum iron, thyroid-stimulating hormone, and liver enzymes were normal. Urine sediment and three stool samples were examined for occult blood, ova and parasites. A colonoscopy, esophagogastroduodenoscopy and an ultrasonographic study of the abdomen and pelvis were performed to exclude an organic disease. Patients were then submitted to a further evaluation of the role of carbohydrate malabsorption. They were divided into two groups: 94 patients who met the Rome criteria for irritable bowel syndrome and 145 patients who had fewer symptoms and did not fulfill these criteria. They were defined as functional complaints.

Seven symptoms were evaluated: abdominal distension (S1), abdominal pain relieved by defecation (S2), pain associated with more frequent stools (S3), pain associated with looser stools (S4), mucus per rectum (S5), frequent feeling of post-defecation incomplete evacuation (S6), and diarrhea or constipation (S7). (Diarrhea was defined as more than three bowel movements each day, and constipation as fewer than three bowel movements each week).

Carbohydrate malabsorption was studied by means of breath tests measuring hydrogen and methane concentration following oral ingestion of sugar aqueous solutions. On three separate occasions, at weekly intervals and after an overnight fast, patients were given a lactose solution (18 g), then a fructose solution (25 g) and finally a mixture of fructose and sorbitol (25 g and 5 g respectively). A solution of sorbitol alone was not tested. In order to reduce baseline hydrogen concentration to minimal levels patients were instructed to maintain a diet free of carbohydrates and fiber the day before each test. End-expiratory breath samples were collected before and every 30 minutes for 4 hours following sugar ingestion. Hydrogen and methane breath concentrations were measured by gas chromatography (Quintron, Model DP Microlyzer, Quintron Instruments Co., Inc., USA). Patients were instructed not to smoke or sleep during the test, and to rest. The following data were determined in the three breath test sessions:

- Orocecal transit time, defined as the period from ingestion until the appearance of a sustained rise in breath hydrogen concentration of 10 ppm or more.
- Peak of hydrogen or methane concentrations defined as maximal increments of hydrogen or methane measured from the lowest baseline values.
- Time of maximal hydrogen or methane peak.

Incomplete absorption of carbohydrate(s) was defined as an increment in breath hydrogen of at least 20 ppm or its equivalent in methane of 5 ppm or more [11].

Symptom score during breath tests

During the test period the patients recorded the appearance of gastrointestinal symptoms, which were given the following score: general discomfort = 1, abdominal discomfort = 2, flatulence = 3, abdominal pains = 4, and diarrhea = 5. A total symptom score ranging from 0 to 15 was calculated for each subject.

Improvement index after one month of dietary restriction

With the completion of the three breath test sessions and according to the results obtained, a dietary restriction free of the offending sugar(s) was instituted by a clinical dietician. Responses to the dietary trial were recorded weekly for one month by the patient and graded as follows: group 1 = full improvement, group 2 = substantial improvement, group 3 = slight improvement, and group 4 = no improvement at all. The compliance to the diet was also recorded: 1 = strict compliance, 2 = partial compliance, and 3 = no compliance. In addition, at the end of the dietary trial each participant was asked to note which of the seven symptoms (S1–S7) still remained.

Statistical analysis

Non-parametric statistical tests based on ranks were used. Differences between groups were assessed by the Mann-Whitney test. Symptoms before and after the diet, and breath parameters of various carbohydrate tests were compared by the Wilcoxon test. Correlations between variables were assessed by the Spearman test. Differences between proportions were evaluated by the Chi-square test. Significance was set at $P<0.05$.

Results

In the study group of 239 patients 94 met the Rome criteria for IBS and 145 had fewer symptoms and were defined as having FC. There was no difference in age and gender between these two groups. In the IBS group we found no difference in age between women and men (44.4±17.5 years for women, 42.7±18.6 for men). In contrast, in the FC group the mean age of men was significantly lower than that of women (35.7±15.7 vs. 49.6±18.9, $P<0.001$). In the FC group 65% of men and only 28% of women were below age 40 ($P<0.01$). In the IBS group 43% of men and 49% of women were under 40.

Significant differences were observed in IBS and FC groups when gastrointestinal symptoms (S1-S7) were compared (at least $P<0.01$) [Figure 1]. The major differences were observed in the following symptoms: abdominal pain associated with more frequent stools (S3), abdominal pain associated with looser stools (S4), mucus per rectum (S5), and feeling of incomplete evacuation after defecation (S6).

Breath test parameters

There were no significant differences between IBS and FC groups in any of the following parameters examined: score of symptoms during the test, H_2 and CH_4 maximal rise, time of maximum concentration of H_2 and CH_4 and orocecal transit time. In both groups H_2 maximal rise and the time of H_2 peak were significantly lower in the fructose and fructose-sorbitol tests as compared to lactose ($P<0.01$). More than 70% of patients reported symptoms during the tests. Symptom score was correlated with the degree of H_2 maximal rise ($P<0.01$).

Sugar malabsorption

No differences were found in the pattern of sugar malabsorption between IBS and FC patients. Only 7% of IBS and 8% of FC subjects were negative for all three tests. Two main patterns were noted: lactose/fructose-sorbitol malabsorption (27% of IBS and 29% of FC patients) and lactose/fructose/fructose-sorbitol malabsorption (34% of IBS and 32% of FC patients). These two groups with associated lactose and fructose-sorbitol malabsorption constituted 61% of all patients. The frequency of isolated lactose malabsorption was 16% in IBS and 12% in FC patients [Figure 2].

The frequency of sugar malabsorption, isolated or combined, among patients in both groups was 78% for lactose malabsorption (IBS 82%, FC 75%), 44% for fructose malabsorption (both groups), and 73% for fructose-sorbitol malabsorption (IBS 70%, FC 75%) [Figure 3].

Restriction diet

After one month on the diet without the offending sugar(s), patients were asked to record their symptoms, the degree of improvement, and their compliance to the diet. Only 73 patients returned the questionnaire – 30 of 87 IBS (34%) and 43 of 133 FC (32%). The compliance was better among women (39%) than among men (26%). More women answered the questionnaire in both groups (19/30 IBS, 63%; 30/43 FC, 70%) and they were older than the original cohort (IBS 60±9 vs. 44±17 years, $P<0.01$; FC 60±15 vs. 50±19, $P<0.01$). Among the respondents, the age of the men was similar to the original cohort (IBS 44±24 vs. 43±19, FC 36±17 vs. 36±16).

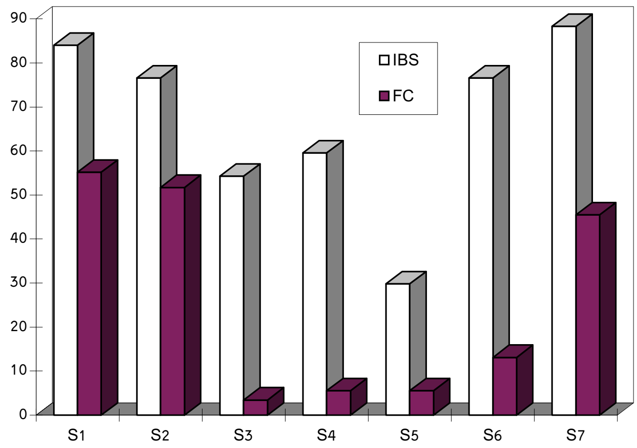

Figure 1. Frequency of symptoms in IBS and FC groups. S1 = abdominal distension, S2 = pain relief with defecation, S3 = more frequent stools at pain onset, S4 = looser stools at pain onset, S5 = mucus per rectum, S6 = feeling of incomplete evacuation, S7 = diarrhea or constipation. $P<0.01$ IBS vs. FC for each symptom.

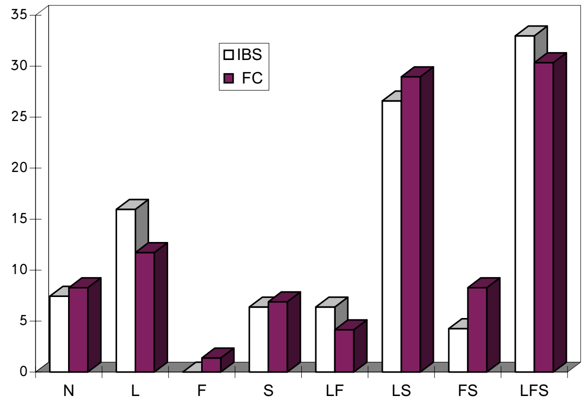

Figure 2. Frequency of various malabsorption patterns in IBS and FC patients. L = lactose, F = fructose, S = fructose-sorbitol.

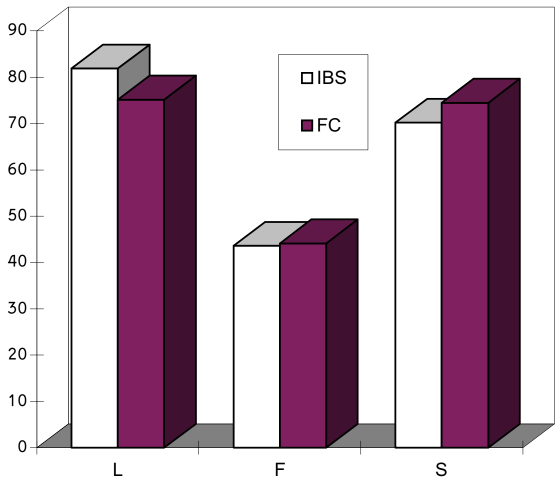

Figure 3. Malabsorption frequency of three sugar solutions.

Table 1. Number of symptoms before and after the institution of dietary restriction

Improvement index	Irritable bowel syndrome			Functional complaints		
	Before diet	After diet	*P*	Before Diet	After diet	*P*
1	4.3	1.4	0.032	2.1	0.6	<0.02
2	4.9	2.8	0.016	2.1	1.0	<0.02
3	4.2	2.4	<0.02	2.3	1.5	0.016
4	4.2	2.8	n.s.	2.3	1.8	n.s.

The number of symptoms are represented as means

The improvement index after one month of dietary restriction of the offending sugar(s) did not differ between IBS and FC patients. More than 50% of the respondents experienced substantial improvement (improvement index 1 or 2: 16/30 IBS, 56%; 26/43 FC, 60%). The improvement after the diet was not linked to the initial number of symptoms. A significant reduction in the total number of symptoms was observed in both groups ($P<0.001$). The number of symptoms before and after the institution of the diet is shown in Table 1. In both IBS and FC patients the decrease in number of symptoms following the diet was significant in the three improvement index groups 1, 2 and 3. Moreover, the magnitude of reduction in the total number of symptoms after one month on the diet was correlated with the improvement index (IBS: r=-0.360, one-tail P=0.025; FC: r=-0.303, one-tail $P<0.025$). Most patients in both groups (70% IBS and 67% FC) kept the diet strictly; the remainder kept the diet partially.

Discussion

The first point made in our study is that combined sugar malabsorption patterns are by far more common than isolated sugar malabsorption. Most patients demonstrated a combined lactose-fructose-sorbitol malabsorption, while the frequency of isolated lactose malabsorption was only 12–16%. The significance of a positive lactose breath test in a patient with functional bowel disorder is that fructose and sorbitol malabsorption are likely to coexist. In our study 61% of patients had combined sugar malabsorption. This implies, therefore, that all three sugars should be eliminated from the diet if a therapeutic trial of dietary restriction is instituted, unless specific hydrogen breath tests are performed for the exact characterization of the offending carbohydrates.

The second point is that dietary restriction of the offending sugar should be instituted before drug therapy is prescribed, as evidenced by the significant improvement – 56% among IBS and 60% among FC patients. This is probably a more important issue, since efficacy of therapeutic modalities currently available for the treatment of irritable bowel syndrome and functional bowel complaints are limited and disappointing in many patients.

Previous studies have shown the frequency of sugar malabsorption in healthy volunteers and in patients with functional bowel complaints [2–7]. Sorbitol malabsorption was reported in 62%, 90% and 100% of healthy volunteers according to the amount of sorbitol ingested – namely 6.8 g, 10 g, and 20 g, respectively [13]. Another study [3], which compared fructose-sorbitol malabsorption in 73 patients with irritable bowel syndrome and in 87 controls, found malabsorption in 22 of the patients (30%) and 35 of the controls (40%). Symptoms developed during the hydrogen breath test in 31 of 70 patients and in 3 of 85 control subjects [3]. This study also showed that fructose-sorbitol malabsorption was not more frequent in IBS patients than in control subjects. Yet another study [7] examining lactose, fructose and sorbitol malabsorption in 520 patients with functional dyspepsia found that fructose and sorbitol were closely linked with respect to absorption or malabsorption. In contrast to lactose, ethnic origin was not found to influence fructose and sorbitol malabsorption patterns. However, the high prevalence in our population, and the different frequencies of fructose and sorbitol malabsorption reported from different parts of the world suggest the possible importance of ethnic origin [3,5,12]. Banares [5] studied the effect of sugar malabsorption on symptoms in 25 outpatients diagnosed with functional bowel disorders and in 12 healthy subjects. The frequency of sugar malabsorption was high in both the patient and control groups, with malabsorption of at least one sugar in more than 90% of subjects. Symptom score following both lactose or fructose plus sorbitol administration was significantly higher in patients than in controls. Symptoms improved in 40% of patients after restriction of the offending sugar. The results suggested that sugar malabsorption may be implicated in the development of symptoms in at least a subset of patients with functional bowel complaints [5]. In our study 56–60% of patients improved significantly after one month on a restriction diet.

Fructose, a naturally occurring 6-carbon monosaccharide, is increasingly used as an added sweetener in processed foods. It is also found in modern diets as a constituent of the disaccharide sucrose. Fructose is abundant in fruit and honey [5,7]. The capacity for fructose absorption is limited compared with that of glucose [13,14]. The simultaneous ingestion of glucose may prevent fructose malabsorption. Sorbitol is a 6-carbon hexahydroxyalcohol used as a sugar substitute in many dietetic foods and as a drug vehicle. It is also abundant in certain fruits [5,7]. Fructose-sorbitol malabsorption occurs more frequently at lower combined doses of fructose and sorbitol than in separate doses [15].

Genetic origin controls the absorption of lactose, which depends on the concentration and activity of lactase. No enzymatic reactions are involved in the absorption of fructose and sorbitol, which occur via low capacity facilitated diffusion, as well as a high capacity glucose co-transport pathway in the case of fructose [2,16]. Fructose-sorbitol malabsorption patterns have not yet been attributed to genetic origin.

Doctors and patients alike should be more aware of the possible importance of fructose and sorbitol to the contribution of symptoms, as they are aware regarding lactose. Our present study shows that sugar malabsorption patterns are generally combined and should be treated for at least one month before other treatment modalities are considered for the treatment of functional bowel disorders.

We recognize that two important pitfalls exist in our study: the relatively short follow-up, and the absence of a placebo diet as a control group. These limitations should encourage others to pursue the role of carbohydrate malabsorption in the management of patients with functional bowel disorders.

Acknowledgements: The authors wish to thank Mrs. Hana Nissim for her devoted contribution to the dietary program. This work was supported by the Lori and Bernard Levmore Gastroenterology Research Fund.

References

1. Feldman M, Scharschmidt BF, Sleisenger MH. Sleisenger and Fordtran's Gastrointestinal and Liver Disease. Pathophysiology. Diagnosis. Management. Sixth ed. Philadelphia: WB Saunders, 1998:1537.
2. Rumessen JJ, Gudmand-Hoyer E. Functional bowel disease: malabsorption and abdominal distress after ingestion of fructose, sorbitol and fructose-sorbitol mixtures. *Gastroenterology* 1988;95:694–700.
3. Nelis GF, Vermeeren MA, Jansen W. Role of fructose-sorbitol malabsorption in the irritable bowel syndrome. *Gastroenterology* 1990;99:1016–20.
4. Lembcke B. Carbohydrate malabsorption (fructose, sorbitol) and functional intestinal disorders. *Z Gastroenterol* 1989;27:148–50.
5. Fernandez-Banares F, Esteve-Pardo M, de Leon R, Humbert P, Cabre E., Lovet JM, Gassullm A. Sugar malabsorption in functional bowel disease: clinical implications. *Am J Gastroenterol* 1993;88:2044–50.
6. Gotze H, Mahdi A. Fructose malabsorption and dysfunctional gastrointestinal manifestations. *Monatsschr Kinderheilkd* 1992;140:814–17.
7. Mishkin D, Sablauskas L, Yalovsky M, Mishkin S. Fructose and sorbitol malabsorption in ambulatory patients with functional dyspepsia. *Dig Dis Sci* 1997;42:2591–8.
8. Mayer EA, Gebhart GF. Basic and clinical aspects of visceral hyperalgesia. *Gastroenterology* 1994;107:271–4.
9. Kamath PS, Philips SF, Zinmeister AR. Short-chain fatty acids stimulate ileal motility in humans. *Gastroenterology* 1988;95:1496–502.
10. Yajima T. Contractile effect of short-chain fatty acids on the isolated colon of the rat. *J Physiol* 1985;368:667–9.
11. Strocchi A, Levitt MD. Factors affecting hydrogen production and consumption by human fecal flora: the critical role of hydrogen tension and methanogenesis. *J Clin Invest* 1992;89:1304–11.
12. Corazza GR, Strocchi A, Rossi R, Sirola D, Gusbarrini G. Sorbitol malabsorption in normal volunteers and in patients with celiac disease. *Gut* 1988;29:44–8.
13. Ravich WJ, Bayless TM, Thomas M. Fructose: incomplete intestinal absorption in humans. *Gastroenterology* 1983;84:26–9.
14. Rumessen JJ, Gudmand-Hoyer E. Absorption capacity of fructose in healthy subjects. Comparison with sucrose and its constituent monosaccharides. *Gut* 1986;27:1161–8.
15. Rumessen JJ, Gudmand-Hoyer E. Malabsorption of fructose-sorbitol mixture; interactions causing abdominal distress. *Scand J Gastroenterol* 1987;22:431–6.
16. Rumessen JJ. Fructose and related food carbohydrates. Sources, intake, absorption and clinical implications. *Scand J Gastroenterol* 1992;27:819–28.

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