Bloating and abdominal distention are common and bothersome symptoms, for which clear pathophysiologic explanations have been lacking and available treatment options are limited. Bloating refers to the subjective sensation of abdominal swelling, whereas visible abdominal distention refers to an actual increase in abdominal girth. A recent population-based study demonstrated an age- and gender-adjusted prevalence in the US white population of bloating to be 19%, whereas visible distention was observed in 9%. In this survey, associations with female gender and somatization were seen, as well as with the presence of functional gastrointestinal (GI) disorders. This is in line with investigations in patients with functional bowel disorders, such as irritable bowel syndrome (IBS), where a majority complains of bloating with or without visible abdominal distention and many find these to be among their most bothersome symptoms. For long, abdominal bloating and visible distention have been poorly understood symptoms, but recent studies, especially from the Manchester and Barcelona groups, have shed some light on the different mechanisms involved in the generation of these symptoms. This is exemplified in the article by Accarino et al in this issue of GASTROENTEROLOGY, where an important role for abnormal viscerosomatic responses with abdominophrenic incoordination and anterior wall protrusion was demonstrated.

**Bloating versus abdominal distention.** By using abdominal inductance plethysmography and computed tomography (CT) it has been shown convincingly that abdominal distention is a real phenomenon in IBS that can reach up to 12 cm in certain patients. Although a sensation of bloating and visible abdominal distention often occurs together, this is not always the case, and in patients with IBS complaining of bloating, approximately half of the subjects objectively demonstrated visible abdominal distention, which is in line with reports from population-based studies. In this group of patients, constipation was more common and visceral hyposensitivity was observed frequently. The other 50% of patients complain of bloating alone without visible abdominal distention, and in this subgroup of patients, diarrhea predominance seems to be more common and the patients more often have signs of visceral hypersensitivity. Moreover, in a recent barostat study from our group we also demonstrated that altered rectal perception was associated with the severity of bloating, further supporting this link. Based on these results, it seems as if bloating and visible abdominal distention share some features, but may arise from distinct pathophysiologic processes.

**Excessive amounts of gas in the GI tract?** A vast majority of patients with IBS complaining of bloating and abdominal distention are convinced that this is due to having “too much gas” within the GI tract. However, from the early studies using washout techniques and the recent studies from the Barcelona group, where a modern CT image analysis program has been used, it seems clear that excessive amounts of gas in the GI tract is not the main problem in the majority of patients with functional bowel disorder, although abnormal colonic fermentation has been suggested in some studies. However, a defect handling of exogenous gas loads within the GI tract in patients with bloating has been demonstrated convincingly in several studies of patients with IBS complaining of bloating, and the following gas retention reproduced their symptoms. In fact, the majority of patients included in these studies demonstrated gas retention and/or enhanced perception of the exogenous gas load, pointing toward a combination of impaired transit and enhanced sensitivity being responsible for the symptoms. From a mechanistic point of view, altered GI reflex activity and enhanced sensitivity to nutrients have been found to be important factors involved in the impaired gas transit in these patients, as well as in symptom perception. Moreover, by using a scintigraphic technique, the small intestine was found to be responsible for the ineffective gas propulsion in patients complaining of bloating, which is probably contrary to what the majority of researchers had expected; the colon seems to be a more logical choice.

Taken together, these findings tell us that IBS patients do not necessarily need to produce more gas to have gas-related symptoms, but these may instead be owing to motor dysfunction, creating a transport problem, and enhanced visceral sensitivity. Moreover, as will be discussed, focal gas pooling may release abnormal viscerosomatic responses, resulting in bloating and visible abdominal distention.

Abnormal viscerosomatic responses. It has been proposed that depression of the diaphragm, excess lumbar lordosis, weak abdominal musculature, and voluntary protrusion of the abdomen may be of importance in the generation of bloating and abdominal distention, but none of these alterations could be confirmed in an early CT study, or in a small study from Australia where the abdominal wall muscle activity in IBS seemed to be normal. However, by using electromyography of the abdominal wall and the diaphragm, and modern CT image analysis, the group from Barcelona, in a number of careful studies in healthy volunteers and patients, has provided important new knowledge regarding the generation of abdominal distention in patients with functional GI disorders. In these studies, it was demonstrated that abdominal accommodation to volume loads is an active process involving abdominophrenic muscular responses and that patients with IBS and bloating have impaired viscerosomatic reflexes and abdominal wall dystony with failed tonic contraction of the abdominal wall and paradoxical relaxation of the internal oblique in response to a colonic gas load. In the present issue of GASTROENTEROLOGY, these initial pioneering studies are followed by another very interesting study, where a relatively large group of patients with bloating as their predominant complaint and healthy volunteers were investigated with abdominal CT scan, with dedicated software for analyzing the gas content and intra-abdominal volumes. Of great interest, patients with bloating as part of a functional disorder were compared with patients with severe intestinal dysmotility and bloating, and both groups underwent CT scans during basal conditions and during a severe bloating episode. No clear group differences were observed in the basal state. However, different mechanisms behind the bloating episodes were detected in these 2 groups, where patients with intestinal dysmotility demonstrated a true increase in total abdominal volume with cephalic displacement of the diaphragm, whereas the patients with a functional disorder had a very modest increment of the abdominal volume; instead the abdominal distention was related to diaphragmatic descent, resulting in abdominophrenic displacement and ventrocaudal redistribution of contents.

These findings are of potentially great value in explaining the bothersome symptoms of bloating and visible abdominal distention; a minor, although significant, increase in intestinal gas, as demonstrated in this study, may drive the generation of abdominal distention through the presence of abnormal viscerosomatic reflexes. However, this study has some shortcomings. The group with

Figure 1. Potential mechanisms behind bloating and visible abdominal distention in functional GI disorders.
a functional cause of its abdominal distention was selected based on the presence of severe symptoms of bloating and abdominal distention, and comprised patients with IBS with constipation and mixed bowel habits, as well as a group of patients with functional bloating, but no patient with IBS with diarrhea was included. Therefore, from this study, the generalizability of the findings to all patients with a functional bowel disorder is unclear, and the relevance of the findings is confined to patients with visible abdominal distention, not to patients with the sensation of bloating alone. Follow-up studies are now needed in different patient groups with comparisons between different subgroups of patients. Moreover, the role of the body mass index was not clarified in this study.

A new and potentially very important mechanism behind abdominal distention in functional GI disorders has been demonstrated, and the next steps are now to evaluate its relevance relative to other proposed underlying mechanisms, and to find a potential treatment option to reduce these bothersome symptoms.

**Conclusion.** Potential mechanisms behind the bothersome symptoms of bloating and visible abdominal distention have emerged in recent years (Figure 1). Impairment of intestinal gas transit seems to play an important role, implicating a link to altered GI motility—a frequent finding in patients with functional GI disorders. Visceral hypersensitivity, one of the main pathophysiological factors in functional GI disorders, is of importance for symptom generation, especially in those with bloating without visible abdominal distention. Abnormal visceralosomatic responses may result from focal pooling of gut content with abdominophrenic incoordination and abdominal wall protrusion as a consequence. Other less well-established/studied factors of potential importance are abnormal mucosal immune activation, altered bacterial flora, altered sex hormones, and psychological factors, including somatization. The next step now would be to evaluate the relative importance of these differences and the interplay between them. Will subgrouping of patients with bloating alone versus bloating with abdominal distention based on the presence/absence of different pathophysiological factors be clinically relevant? Moreover, from the patients’ point of view, it seems to be of utmost importance to translate these findings into the development of potential treatment options to reduce the severity of bloating and visible abdominal distention. This will be a major step forward for the patients and their treating physicians!

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**References**

High- or Low-Carbohydrate Diets: Which Is Better for Weight Loss, Insulin Resistance, and Fatty Livers?


The recent increase in obesity and the health problems associated with it has grown into a huge public health burden.1 A plethora of diets continue to be promoted to help with weight reduction.2 Many of these are either low-carbohydrate (LC) or high-carbohydrate (HC) diets.2,3 There is continuing debate as to which of these 2 dietary approaches is best with respect to weight loss, reduction in cardiovascular risk including blood pressure and lipid levels, and for patients with diabetes, improvement of blood glucose control. The manuscript by Kirk et al4 in this issue of GASTROENTEROLOGY addresses some of these issues. These authors studied 22 obese (body mass index, 36.5 ± 0.8) men and women, 14 of whom had impaired glucose tolerance; none had overt diabetes. These volunteers were admitted to the General Clinical Research Center (GCRC) at Washington University Medical Center and were randomized to either an HC (carbohydrate ≥180 g/d) or a LC (carbohydrate ≤60 g/d) diet. After 48 hours on these diets, patients were discharged from the GCRC and told to continue on their HC or LC diets at home until they reached a 7% weight loss, which occurred after about 6 weeks. At that time, their caloric intake was adjusted to maintain weight. After approximately 4 weeks on this new weight-maintaining diet, all subjects were readmitted to the GCRC, where the clamps and body composition analyses were repeated.

What were the findings and what can we learn from them? Let us first look at weight loss. Both groups lost about 2 kg during the initial 48 hours in the controlled environment of the GCRC, where their energy intake was around 1100 kcal/d. Their prehospitalization energy intake is not known, but probably was ~3000 kcal/d based on a study with similarly obese subjects where energy intake was measured.5 Thus, assuming no change in energy expenditure, their estimated caloric deficit was approximately 4000 kcal/48 h (≈3,000 – 1100 kcal/d X 2 days).

More important than this initial weight loss, which was mostly a loss of body water,6 was the weight loss which occurred during the first 6 or so weeks during which both LC and HC groups lost about 7 kg or 5,250 g of fat (≈75% of the weight loss was from fat). On average, therefore, they lost about 125 g of fat per day (5250 g/42 days), which translates into an energy deficit of approximately 1000 kcal/d. This suggests that