A Practical Approach to the Diagnosis and Treatment of Abdominal Bloating and Distension

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Abstract: Abdominal bloating and distension are highly prevalent symptoms that can negatively impact quality of life and lead to medical consultation. Despite their prevalence, symptoms of bloating and distension pose a unique diagnostic and therapeutic challenge, as they are inherently nonspecific symptoms with a complex etiology, and no uniform diagnostic or treatment algorithm currently exists. Additionally, bloating is common among disorders of gut-brain interaction, which can be difficult to treat. This article offers a practical approach for evaluating and treating symptoms of bloating and distension through discussion of 5 common etiologies: diet, small intestinal bacterial overgrowth, constipation, visceral hypersensitivity, and abdomino-phrenic dyssynergia. An effective personalized evaluation and treatment plan can be established to address symptoms of bloating and distension through consideration of these etiologies in the context of the patient's individual characteristics and presentation.

Keywords
Bloating, distension, small intestinal bacterial overgrowth, constipation, pelvic floor dysfunction, visceral hypersensitivity, abdomino-phrenic dyssynergia

Abdominal bloating and distension are 2 of the most commonly reported gastrointestinal (GI) symptoms. US household surveys have estimated the prevalence of symptoms of bloating to be 16% to 31%.[1,2] Nearly everyone has experienced occasional symptoms of abdominal bloating or distension, perhaps in the context of a meal. For many people, bloating and distension are infrequent, transient symptoms that do not lead to medical consultation. However, for other people, bloating and distension can be chronic symptoms that are bothersome and negatively impact quality of life, particularly among people with disorders of gut-brain interaction (DGBI), previously called functional GI disorders. For example, in studies of patients with irritable bowel syndrome (IBS), the prevalence of bloating and distension has been reported to be as high as 66% to 90%.[3,4] As such, abdominal bloating has been recognized as a key supporting symptom for IBS in the latest iteration of the Rome criteria (Rome IV), which define DGBI.[5]

Abdominal bloating is the subjective sensation of excess intestinal gas, or a feeling of being distended without obvious visible abdominal distension. Patients with abdominal bloating may also describe a sense of fullness or discomfort in the epigastric area. Abdominal distension

Table 1. Common Organic and Pathologic Etiologies for Abdominal Bloating and Distension

- Lactose, fructose, and other carbohydrate intolerances
- Celiac disease
- Small intestinal bacterial overgrowth
- Pelvic floor dysfunction
- Gastroparesis
- Delayed small intestine transit
- Mechanical obstruction
- Chronic intestinal pseudo-obstruction
- Pancreatic insufficiency
- Hypothyroidism
- Ascites
- Central adiposity
- Prior gastroesophageal surgery (bariatric surgery, fundoplication)
- Gastrointestinal or gynecologic malignancy
- Aerophagia

is the objective physical manifestation of an increase in abdominal girth. Symptoms of abdominal bloating and distension frequently coexist but can occur independently in some patients. The impact of abdominal bloating and distension can be significant among patients with chronic symptoms. However, despite their prevalence, the impact of these symptoms on the health care system as a whole is poorly understood, as symptoms of bloating and distension are typically included in diagnostic codes for IBS, constipation, dyspepsia, and other diagnoses for billing purposes.

The etiology and pathophysiology of bloating and distension are complex, and these nonspecific symptoms often create a diagnostic dilemma for the clinician. Similarly, there is no universally accepted treatment algorithm for bloating, which poses another clinical challenge. Importantly, a number of organic disorders may also cause symptoms of bloating and distension and thus need to be considered, especially if alarm symptoms such as weight loss are present (many of which are beyond the scope of this review; see Table 1). The purpose of this review is to present a practical approach to evaluating and managing symptoms of abdominal bloating and distension through a discussion of 5 key etiologies: diet, small intestinal overgrowth (SIBO), constipation, visceral hypersensitivity, and abdomino-phrenic dyssynergia (Figure 1).

Diet

Many patients implicate diet as a cause for symptoms of bloating and distension. Indeed, a careful diet history can be an important initial step in the evaluation of bloating and distension, as the identification of specific foods that trigger symptoms may assist in management. For example, artificial sweeteners that contain poorly absorbed sugar alcohols, such as sorbitol, mannitol, and glycerol, can promote intestinal gas production.[6] Thus, avoidance of products that contain artificial sweeteners, such as certain diet sodas, chewing gum, and coffee sweeteners, may help reduce symptoms of abdominal bloating and distension in some patients.

Additionally, carbohydrate intolerance and malabsorption represent another important category pertaining to diet and bloating. Lactose is a disaccharide composed of glucose and galactose, and is the main carbohydrate found in milk products. The absorption of lactose is dependent on the brush border enzyme lactase-phlorizin hydrolase. Deficiency of lactase can lead to lactose maldigestion, causing excess intestinal gas production and diarrhea. A recent meta-analysis estimated the prevalence of lactose malabsorption to be 68% globally and 36% in the United States.[7]

Although there is currently no gold standard test, assessment of lactose malabsorption is commonly performed with a hydrogen breath test using lactose as a substrate. An increase of at least 20 ppm breath hydrogen above baseline is considered to be a positive test.[8] It should be noted, however, that variations in testing methodology can affect the rate of false-positive and false-negative results with carbohydrate breath testing in general, and there is controversy pertaining to the clinical utility of carbohydrate breath testing, including lactose breath testing.[9] Although some centers have historically used 50 g of lactose for lactose breath testing, the most recent North American Consensus guidelines recommend that 25 g of lactose is the correct dose for lactose breath testing.[8] Importantly, lactose intolerance does not necessarily correspond with lactose malabsorption by a breath test, and lactose intolerance is thought to be particularly prevalent among patients with DGBI. A recent meta-analysis demonstrated that lactose intolerance was significantly more common in patients with IBS compared with healthy controls (odds ratio, 3.49; 95% CI, 1.62-7.55), whereas there was no significant difference in the prevalence of lactose malabsorption between IBS patients and controls.[10]

Fructose is a part of the disaccharide sucrose (also containing glucose) and is a naturally occurring sugar in fruits, vegetables, and sweeteners. Absorption of fructose occurs via the glucose/fructose transporter member 5 (GLUT5) in the small intestine, although absorptive capacity is thought to be limited and is partially dependent on glucose.[11] The limited absorptive capacity of fructose in healthy individuals is important to highlight, as

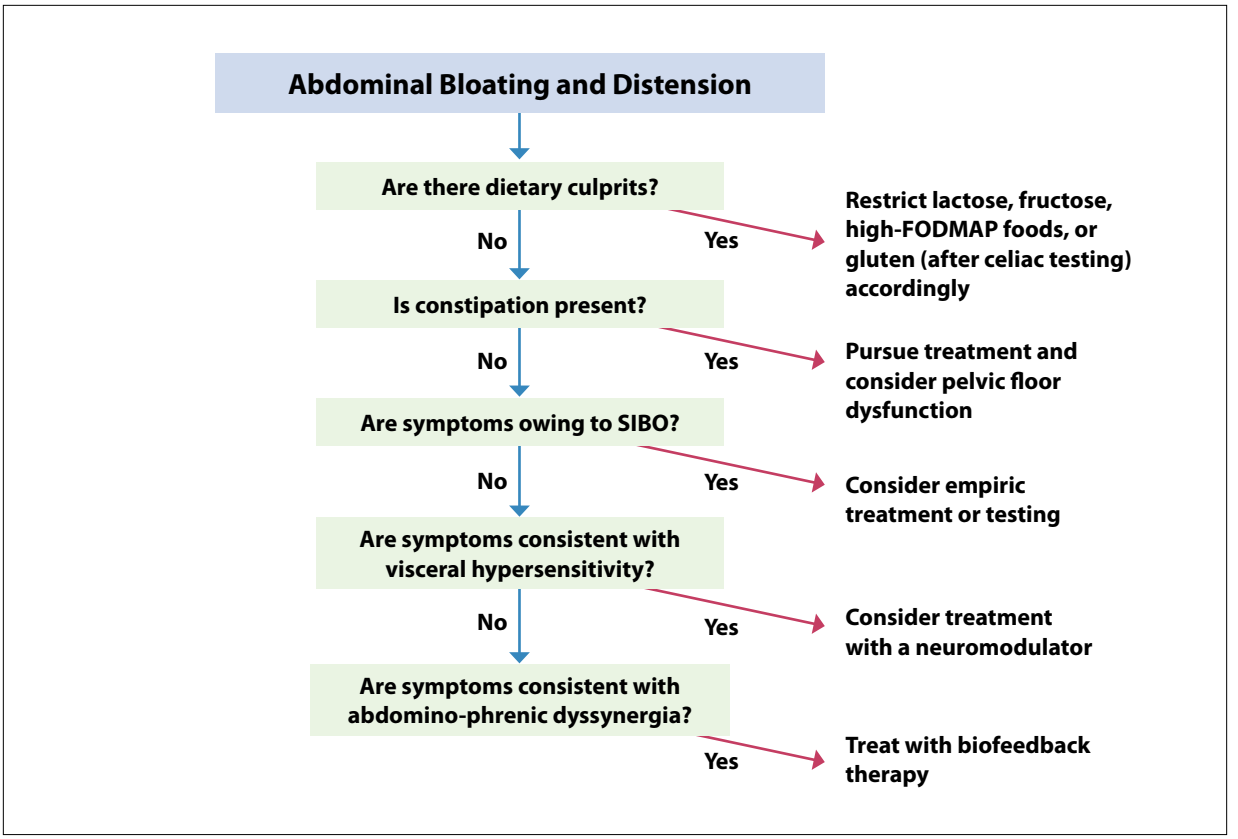

Figure 1. Recommended treatment algorithm for abdominal bloating and distension in the absence of alarm symptoms.
FODMAP, fermentable oligosaccharide, disaccharide, monosaccharide, and polyol; SIBO, small intestinal bacterial overgrowth.

there is no controversy regarding the amount of fructose to use as a substrate during a hydrogen breath test, which is the test of choice for assessing fructose malabsorption. The most recent North American Consensus guidelines recommend using 25 g of fructose for breath testing and, as mentioned, consider a rise of at least 20 ppm in breath hydrogen from baseline to represent a positive result.[8] As with lactose breath testing, the clinical utility of fructose breath testing has been questioned, given the potential for false-positive and false-negative results, and multiple studies have demonstrated intra-individual variability with repeated fructose testing.[9]

Gluten, a storage protein found in certain grains, is another dietary source that can cause symptoms of bloating and distension in some patients (especially those with celiac disease), although the potential for gluten to cause bloating in patients without celiac disease is debated. In celiac disease, malabsorption of wheat and gluten injures the villi of the small intestine, leading to decreased brush border enzyme activity, altered breakdown of carbohydrates, and an increased osmotic load in the small intestine, which can lead to symptoms of bloating, distension, and accelerated GI transit.[12] An estimated 70% of patients considered to have nonceliac gluten sensitivity (NCGS) report bloating as a symptom.[13] Gluten has also been implicated as a dietary element that can cause bloating in patients with DGBI. A randomized, placebo-controlled, rechallenge trial of 34 patients with IBS (without celiac disease), who were symptomatically controlled on a gluten-free diet, demonstrated that a 1-week gluten challenge led to significantly worse bloating compared with placebo.[14] Importantly, more recent evidence demonstrates that fructans (oligo- or polysaccharides consisting of chains of fructose with a single terminal glucose molecule), which are also present in wheat, may be the culprit for symptoms in patients with NCGS, rather than gluten.[15] Further, a double-blind crossover trial of 37 patients with NCGS and IBS failed to show a dose-dependent effect of gluten on symptoms, whereas all patients experienced significant improvement in symptoms when placed on a low–fermentable oligosaccharide, disaccharide, monosaccharide, and polyol (FODMAP) diet during a 2-week run-in period.[16]

Studies have shown that IBS patients treated with a low-FODMAP diet reported statistically significant improvement in bloating compared with standard dietary

Table 2. Risk Factors for Small Intestinal Bacterial Overgrowth

Anatomic Abnormalities
• Gastrointestinal surgery (Roux-en-Y gastric bypass, ileocecal valve resection) • Small bowel stricture or fistula • Short bowel syndrome • Small bowel diverticulosis • Small bowel intussusception
Gastrointestinal and Motility Disorders
• Gastroparesis • Delayed small bowel transit • Chronic intestinal pseudo-obstruction • Celiac disease • Pancreatic insufficiency • Atrophic gastritis
Systemic Disorders
• Connective tissue disorders (scleroderma, Ehlers-Danlos syndrome) • Amyloidosis • Immune deficiency (immunoglobulin A deficiency, combined variable immune deficiency) • Diabetes mellitus • Hypothyroidism • Cirrhosis • Paraneoplastic syndrome
Medications
• Proton pump inhibitors • Opioids • Anticholinergics

advice.[17,18] Further, a study by Böhn and colleagues also showed statistically significant improvements in abdominal distension in patients with IBS treated with a low-FODMAP diet compared with pre-diet intervention baseline.[19] However, a recent meta-analysis of 13 randomized controlled trials (RCTs) assessing a low-FODMAP diet for the treatment of IBS demonstrated that a low-FODMAP diet was superior to British Dietetic Association/National Institute for Health and Care Excellence dietary advice with respect to improving symptoms of bloating or distension but was not found to be superior to other dietary strategies, including a high-FODMAP diet.[20] Taken together, a trial of a low-FODMAP diet is still considered to be a reasonable dietary intervention to treat symptoms of bloating and distension. Indeed, the most recent guidelines for the management of IBS released by the American College of Gastroenterology recommend a limited trial of a low-FODMAP diet to improve global symptoms of IBS, including bloating.[21] However, the clinician should be advised that a long-term treatment strategy centered on a low-FODMAP diet is best done in conjunction with a trained GI nutritionist, as proper reintroduction of foods is important for avoiding micronutrient deficiencies that may develop with chronic low-FODMAP diet adherence.

Small Intestinal Bacterial Overgrowth

SIBO is characterized by the presence of excess bacteria within the small intestine, combined with characteristic GI symptoms such as bloating. Thus, SIBO is frequently considered in the evaluation of patients with bothersome bloating or distension and may be particularly relevant in patients with identifiable risk factors that may predispose them to SIBO (Table 2). However, there is considerable controversy regarding the diagnosis of SIBO and the clinical utility of current testing methods. Historically, aspiration with culture of fluid within the small intestine has been considered the gold standard for diagnosis of SIBO. However, this technique is inherently invasive, as the fluid sample is obtained via upper endoscopy. Breath testing represents an alternate method for SIBO testing that is safe, noninvasive, less expensive, and relatively easy to perform. As such, breath testing has become a generally accepted and increasingly popular means of testing for SIBO, although its sensitivity is modest and estimated to range from 20% to 93%.[22,23] Glucose or lactulose can be utilized as substrates for hydrogen and methane breath testing in the assessment for SIBO. Per the most recent North American Consensus guidelines, a lactulose or glucose breath test is considered positive for SIBO if breath hydrogen levels rise by 20 ppm or more compared with baseline within 90 minutes.[8]

Given the lack of consensus regarding the optimal method to diagnose SIBO, its true prevalence and association with other pathologic disorders remain uncertain. For example, the prevalence of SIBO among healthy controls has been reported to be 0% to 20%, vs 4% to 78% in patients with IBS.[24] Additionally, recommendations regarding management of SIBO have also been somewhat limited by controversies surrounding its diagnosis. However, many clinicians would agree that identification of potential underlying causes, and correction if possible (ie, small bowel stricture), is a reasonable first step.

For the majority of people in whom no specific etiology can be identified, antibiotic treatment is frequently pursued. Although no uniformly accepted antibiotic treatment algorithm exists, rifaximin (Xifaxan, Salix), a poorly absorbed antibiotic with a favorable safety profile,

Table 3. Antibiotic Treatment Options for Small Intestinal Bacterial Overgrowth

- Ciprofloxacin (250 mg BID)
- Doxycycline (100 mg BID)
- Metronidazole (250 mg TID)
- Neomycin (500 mg BID)
- Norfloxacin (400 mg BID)
- Rifaximin (550 mg TID)
- Tetracycline (250 mg QID)
- Trimethoprim-sulfamethoxazole (160/800 mg BID)

BID, twice daily; QID, 4 times daily; TID, 3 times daily.

has been the most commonly studied for treatment of bloating symptoms (see Table 3 for a comprehensive list of antibiotic treatment options). Although the precise mechanism of action of rifaximin remains unclear, there is evidence that the response to rifaximin may be related to the presence of SIBO. For example, 1 placebo-controlled trial of more than 100 patients with symptoms of bloating and flatulence, with over one-half meeting Rome II criteria for IBS, demonstrated that a significant decrease in hydrogen breath excretion on breath testing correlated with an improvement in bloating among those who responded to rifaximin.[25] However, rifaximin has also been shown to be effective in treating bloating in patients with DGBI, irrespective of SIBO. In 2 identical, placebo-controlled trials (TARGET 1 and TARGET 2) involving more than 1000 combined patients, Pimentel and colleagues identified that patients with IBS without constipation who were treated with rifaximin 550 mg 3 times daily for 14 days had a greater proportion of relief of IBS-related bloating for at least 2 of the first 4 weeks of treatment, compared with those given placebo (40.2% vs 30.3%; $P<.001$).[26] Additionally, rifaximin was shown to be superior to placebo in providing adequate relief of postprandial fullness or bloating in an RCT of 86 patients with functional dyspepsia (FD) according to Rome III criteria without SIBO (80% vs 59%; $P=.03$).[27]

Taken together, although controversy persists regarding the diagnosis and treatment of SIBO, as well as the relevance of SIBO with respect to DGBI, SIBO is still a reasonable consideration in the approach to patients with bloating and/or distension. In patients with identifiable risk factors for SIBO, correction of such factors, if possible, or empiric treatment for SIBO with an antibiotic is logical. However, there are no RCTs comparing one antibiotic to another for the treatment of SIBO, and thus the choice of antibiotic should be based on prior antibiotic use, cost, safety, and an assessment of comorbid conditions and medications. For patients without identifiable risk factors for SIBO, assessment with breath testing or empiric treatment in select populations (ie, those with IBS with diarrhea) is reasonable.

Constipation

Chronic constipation has been estimated to affect approximately 15% of adults, and bloating is a bothersome symptom for many of these patients.[28,29] A prospective study of more than 2000 patients with functional constipation (FC) and IBS with constipation (IBS-C) demonstrated that over 90% of patients reported symptoms of bloating; moreover, patients with bloating reported lower quality-of-life scores.[30] Patients with primary chronic constipation (constipation not attributable to another disease) can be classified based on assessment of colonic transit and anorectal function. Colonic transit can be assessed by radiopaque-marker radiograph study, scintigraphy, wireless motility capsule, or, less commonly, colonic manometry, and patients with delayed colonic transit identified upon testing can be classified as having slow-transit constipation.[31] Altered GI motility generally results frequently in symptoms of bloating. In a study of 30 patients with IBS-C, those with prolonged colonic transit were shown to have greater abdominal distension compared with patients with normal transit; however, symptoms of bloating did not correlate with colonic transit.[32]

Pelvic floor dysfunction, characterized by incomplete relaxation or paradoxical contraction of the puborectalis muscle and/or anal sphincter muscles (so-called dyssynergic defecation), represents an important category of defecatory disorders that can contribute to symptoms of chronic constipation. A meta-analysis of 79 studies assessing prevalence of defecatory disorders in over 7000 patients with chronic constipation identified the prevalence of dyssynergic defecation to be nearly 50%.[33] Anorectal manometry with balloon expulsion is the most widely used test for evaluation of pelvic floor dysfunction.[34,35] Patients with anorectal motor dysfunction may experience bloating and distension because of an impaired ability to effectively evacuate gas or stool from the rectum. One study showed that prolonged balloon expulsion on anorectal manometry correlated with symptoms of distension among patients with constipation.[36] Further, pelvic outlet obstruction has been shown to delay colonic transit.[37] Thus, abdominal bloating and distension may occur in patients with pelvic floor dysfunction owing to the impaired passage of flatus and stool, but also as a result of coexisting slow colon transit.

Pelvic floor dysfunction is most commonly treated with pelvic floor physical therapy, and ideally biofeedback therapy in which patients are trained to effectively relax

Table 4. Rome IV Diagnostic Criteria for Functional Constipation and Irritable Bowel Syndrome With Constipation[a]

Diagnostic Criteria for Functional Constipation[b]
1. Must include 2 or more of the following: • Straining during more than 25% of defecations • Lumpy or hard stools with more than 25% of defecations • Sensation of incomplete evacuation with more than 25% of defecations • Manual maneuvers to facilitate more than 25% of defecations • Fewer than 3 spontaneous bowel movements per week
2. Loose stools are rarely present without the use of a laxative
3. Insufficient criteria for irritable bowel syndrome
Diagnostic Criteria for Irritable Bowel Syndrome[b]
Recurrent abdominal pain, on average, at least 1 day per week in the past 3 months, associated with 2 or more of the following criteria:
1. Related to defecation
2. Associated with a change in the frequency of the stool
3. Associated with a change in the form of the stool
Irritable bowel syndrome with predominant constipation: More than 25% of bowel movements with Bristol stool form type 1 or 2 and less than 25% of bowel movements with Bristol stool form type 6 or 7

[a]Modified from Lacy et al.[5]
[b]Criteria must be fulfilled for the past 3 months with symptom onset at least 6 months prior to diagnosis.

their pelvic floor and abdominal muscles through observation of visual signaling, often generated by real-time electromyography (EMG) measurements from the anal canal and abdomen. In addition to addressing dyssynergic defecation, biofeedback therapy has also been shown to improve symptoms of bloating. In a study of 52 patients with slow transit constipation, biofeedback therapy was shown to significantly reduce symptoms of bloating in patients with pelvic dyssynergia and pelvic outlet obstruction.[37] Additional studies of patients with idiopathic constipation and various combinations of pelvic floor dysfunction and slow colonic transit have demonstrated significant reductions in bloating symptoms following biofeedback therapy.[38,39]

Finally, a large percentage of patients with primary chronic constipation may be categorized as having FC (also referred to as chronic idiopathic constipation [CIC]) or IBS-C. The Rome IV criteria are primarily symptom-based and used to define these 2 disorders; importantly, the presence of abdominal pain associated with a change in bowel habits distinguishes IBS-C from FC (Table 4).[5] A variety of treatment modalities exists for these disorders, although it is important for the clinician to recognize that some treatments can cause bloating, especially the nonabsorbable disaccharide lactulose (ie, insoluble fiber, polyethylene glycol–based solutions).[27,30] As stated previously, symptoms of bloating have been reported in up to 90% of patients with FC and IBS-C. Although impaired colonic transit may contribute to bloating in some patients with FC or IBS-C, heightened visceral hypersensitivity may also contribute to symptoms of bloating (as discussed in the following section) with these disorders.

Secretagogues represent a category of prescription medications that have been shown to improve global symptoms of IBS and FC, including bloating. Three different secretagogues are available to treat symptoms of IBS and CIC: the type 2 chloride channel agonist lubiprostone and the guanylate cyclase-C agonists linaclotide and plecanatide (Trulance, Salix). In a placebo-controlled study of more than 1000 patients with IBS-C, lubiprostone 8 mcg twice daily significantly improved bloating symptoms, a secondary endpoint of the trial.[40] A 48-week, open-label study of 248 patients with CIC demonstrated that lubiprostone 24 mcg twice daily improved bloating, although a placebo group was not included.[41]

In 2 placebo-controlled studies evaluating the efficacy and safety of linaclotide 145 mcg or 290 mcg daily in more than 1000 patients with CIC, both doses significantly improved symptoms of bloating during each of the 12-week studies.[42] Of note, 1 study to date has focused on CIC patients with significant complaints of bloating. In that placebo-controlled study of 483 patients with CIC with moderate to severe bloating, linaclotide 145 mcg and 290 mcg once daily significantly improved symptoms of abdominal bloating compared with placebo.[43] Finally, linaclotide has also been shown to improve bloating in patients with IBS-C, as demonstrated in a placebo-controlled trial of 804 patients in which bloating was a secondary endpoint.[44]

Plecanatide has also been shown to improve bloating in patients with CIC and IBS-C. In a placebo-controlled study of more than 1000 patients with CIC, plecanatide 3 mg and 6 mg once daily both significantly improved symptoms of bloating compared with placebo.[45] Additionally, both doses of plecanatide were shown to significantly improve bloating in patients with IBS-C in 2 identically designed, placebo-controlled studies evaluating its efficacy

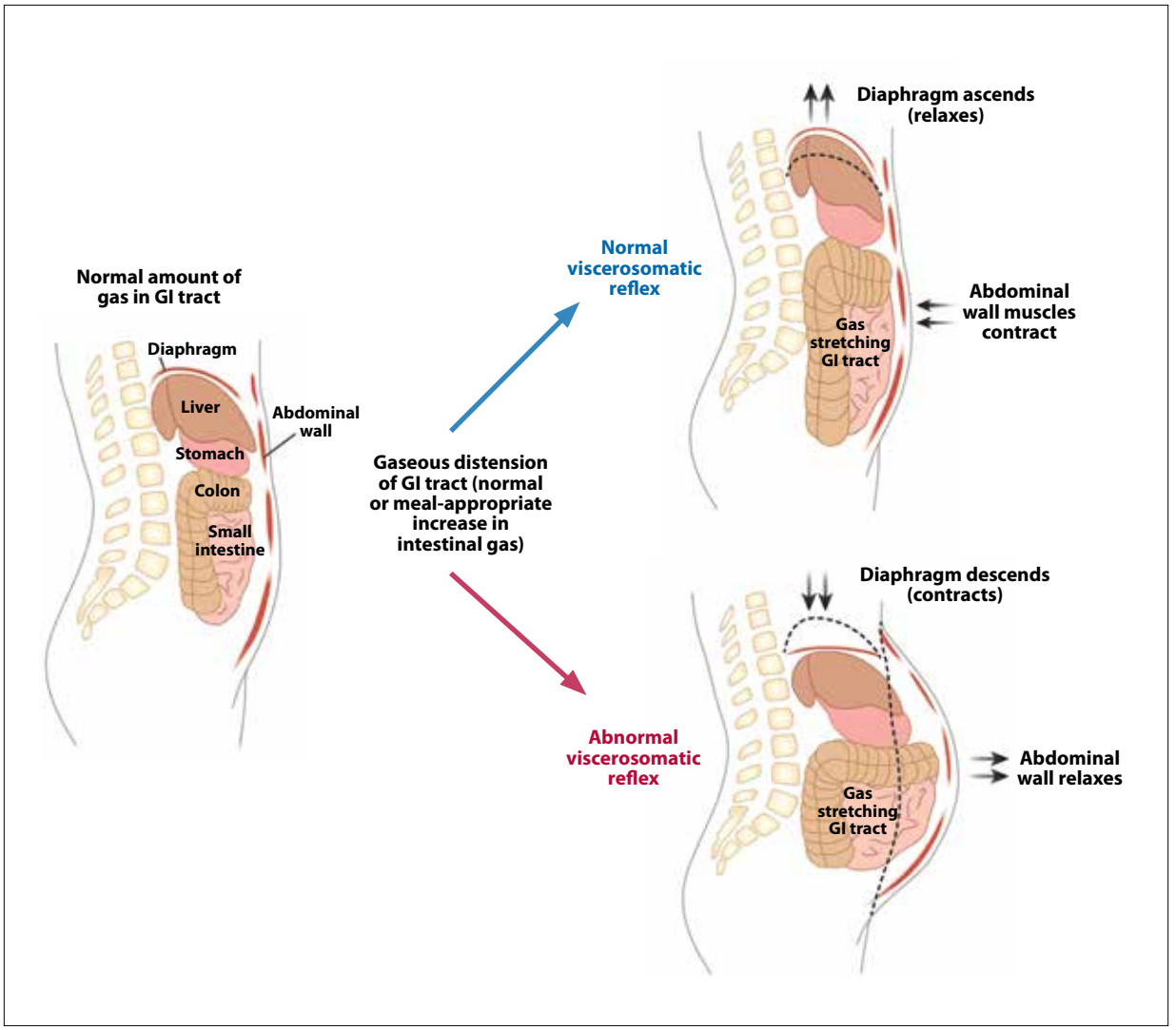

Figure 2. Illustration of abdomino-phrenic dyssynergia. Reproduced with permission from Lacy et al.[63]
GI, gastrointestinal.

and safety for the treatment of IBS-C that included more than 2000 patients combined.[46]

More recently, a meta-analysis of 13 RCTs of medications approved by the US Food and Drug Administration for the treatment of IBS-C that assessed bloating as an endpoint (trials examining linaclotide, lubiprostone, tegaserod [Zelnorm, Alfasigma], and tenapanor [Ibsrela, Ardelyx] were included in the final analysis) demonstrated that these 4 agents were all superior to placebo for relieving bloating, with linaclotide found to be the most efficacious.[47] Thus, secretagogues have consistently been shown to improve symptoms of bloating in patients with FC and IBS-C and should be considered in the treatment of bloating, particularly among patients with constipation that is refractory to more conservative measures, including treatment of pelvic floor dysfunction, if applicable.

Visceral Hypersensitivity

As mentioned, visceral hypersensitivity is thought to play an important role in the pathophysiology of DGBI, including IBS-C. As symptoms of bloating and distension are common in DGBI, heightened visceral hypersensitivity has also been implicated as a mechanism by which symptoms of bloating may occur in this patient population. Using rectal balloon distension, Agrawal and colleagues demonstrated that IBS patients with symptoms of bloating alone had heightened visceral hypersensitivity compared with those with symptoms of bloating and

distension, suggesting that bloating may be a marker for visceral hypersensitivity.[48] Additional studies have also identified a significant association between visceral hypersensitivity and the severity of bloating symptoms among IBS patients.[49] Similarly, in patients with FD, postprandial sensitivity to gastric balloon distension was found to have a significant correlation with postprandial symptoms, including bloating.[50]

As such, centrally acting agents (so-called neuromodulators), such as antidepressants, and peripherally acting agents, such as gabapentin, may be a reasonable treatment option in a select group of patients with bloating, as there is growing evidence that neuromodulators improve symptoms of bloating in patients with DGBI such as IBS and FD.[51-53] One recent placebo-controlled trial of 85 patients with IBS showed that treatment with pregabalin 225 mg twice daily resulted in a significant improvement in bloating symptoms, a secondary endpoint of the trial.[54] In addition to treating visceral hypersensitivity, centrally acting neuromodulators can improve emotional factors, such as anxiety and depression, which may amplify conscious perception of bloating and distension.

Additionally, nonmedicinal alternative therapies, such as cognitive behavioral therapy (CBT) and gut-directed hypnotherapy, have been shown to be effective in the treatment of GI disorders such as IBS and FD, in which bloating is also a common symptom.[55] Although the exact mechanism by which such therapies improve GI symptoms is not completely understood, it is theorized that psychologic therapies address dysfunction of the brain-gut axis, of which visceral hypersensitivity is a central component. Gut-directed hypnotherapy specifically has been shown to attenuate central processing of visceral stimuli in patients with IBS, and has also been shown to significantly improve symptoms of bloating in patients with IBS.[56] Although CBT and gut-directed hypnotherapy have not been studied specifically for bloating, they may become reasonable treatment options for symptoms of bloating related to visceral hypersensitivity as the recognition and application of psychologic-based therapies grow.

Abdomino-Phrenic Dyssynergia

Some patients with abdominal distension develop a paradoxical abdomino-phrenic response to increased intraluminal gas, which is termed abdomino-phrenic dyssynergia. During this process, the diaphragm contracts (descends) and the anterior abdominal wall muscles relax (Figure 2).[57] This response is in contrast to the normal physiologic response to increased intraluminal gas, whereby the diaphragm relaxes and the anterior abdominal muscles contract in order to increase the craniocaudal capacity of the abdominal cavity without abdominal protrusion. In a study by Accarino and colleagues, patients with functional bloating or IBS were shown to have significant abdominal wall protrusion and diaphragmatic descent, as demonstrated by computed tomography scan during an episode of bloating, with relatively small increases in intraluminal gas.[58] In contrast, patients with bloating in the setting of intestinal dysmotility were found to have marked increases in intraluminal gas content with resulting diaphragmatic ascent, which is the expected response to a significant increase in intra-abdominal gas content.[58] Abdomino-phrenic dyssynergia has also been identified in patients with FD and symptoms of postprandial bloating in response to meal ingestion.[59]

Although there is currently no available test to assess for abdomino-phrenic dyssynergia clinically, this maladaptive response has been shown to improve with biofeedback therapy. In a study by Barba and colleagues, biofeedback treatment utilizing visual guidance provided by EMG signal was performed in 26 patients with various DGBI and symptoms of abdominal distension. Biofeedback therapy was shown to result in a significant decrease in EMG activity of the diaphragm and intercostal muscles; additionally, these changes were associated with significant ascent of the diaphragm, decrease in abdominal girth, and improvement in the subjective sensation of abdominal distension.[60] Similarly, in a subsequent placebo-controlled trial involving 44 patients with various DGBI and symptoms of postprandial bloating, Barba and colleagues demonstrated that treatment with biofeedback resulted in reduced intercostal muscle activity, increased anterior wall muscle activity, and reductions in the subjective sensation of both abdominal distension and abdominal girth.[61]

As biofeedback remains a limited resource, diaphragmatic breathing, which is more readily available and has been shown to be effective in treating aerophagia, belching, and rumination syndrome, has been suggested as a potential management option for bloating.[62] Although diaphragmatic breathing has not been studied for the treatment of bloating specifically, it may confer a similar benefit to biofeedback by targeting maladaptive visceromotor reflexes.

Conclusion

Particularly among patients with DGBI, abdominal bloating and distension are highly prevalent symptoms that can negatively affect quality of life and lead to medical consultation. The etiology of bloating is complex and often multifactorial. As symptoms of bloating and distension are inherently nonspecific, evaluation and management can be quite challenging for the practitioner.

This practical review provides a diagnostic and treatment framework for symptoms of bloating and distension, in the absence of alarm symptoms, based on 5 common etiologies: diet, SIBO, constipation, visceral hypersensitivity, and abdomino-phrenic dyssynergia. Considering the aforementioned etiologies in the context of the patient's individual presentation, including dietary triggers, risk for SIBO, presence of constipation, pelvic floor dysfunction, and concomitant DGBI, should facilitate a targeted approach to treating the historically vexing symptoms of abdominal bloating and distension.

Disclosures

Dr Cangemi has no relevant conflicts of interest to disclose. Dr Lacy has served as a consultant for Ironwood, Urovant, Salix, and Viver Health.

References

1. Drossman DA, Li Z, Andruzzi E, et al. U.S. householder survey of functional gastrointestinal disorders. Prevalence, sociodemography, and health impact. *Dig Dis Sci*. 1993;38(9):1569-1580.
2. Sandler RS, Stewart WF, Liberman JN, Ricci JA, Zorich NL. Abdominal pain, bloating, and diarrhea in the United States: prevalence and impact. *Dig Dis Sci*. 2000;45(6):1166-1171.
3. Jiang X, Locke GR III, Choung RS, Zinsmeister AR, Schleck CD, Talley NJ. Prevalence and risk factors for abdominal bloating and visible distention: a population-based study. *Gut*. 2008;57(6):756-763.
4. Drossman DA, Morris CB, Schneck S, et al. International survey of patients with IBS: symptom features and their severity, health status, treatments, and risk taking to achieve clinical benefit. *J Clin Gastroenterol*. 2009;43(6):541-550.
5. Lacy BE, Mearin F, Chang L, et al. Bowel disorders. *Gastroenterology*. 2016;150(6):P1393-P1407.e5.
6. Storey D, Lee A, Bornet F, Brouns F. Gastrointestinal tolerance of erythritol and xylitol ingested in a liquid. *Eur J Clin Nutr*. 2007;61(3):349-354.
7. Storhaug CL, Fosse SK, Fadnes LT. Country, regional, and global estimates for lactose malabsorption in adults: a systematic review and meta-analysis. *Lancet Gastroenterol Hepatol*. 2017;2(10):738-746.
8. 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(5):775-784.
9. Yao CK, Tuck CJ. The clinical value of breath hydrogen testing. *J Gastroenterol Hepatol*. 2017;32(suppl 1):20-22.
10. Varjú P, Gede N, Szakács Z, et al. Lactose intolerance but not lactose maldigestion is more frequent in patients with irritable bowel syndrome than in healthy controls: a meta-analysis. *Neurogastroenterol Motil*. 2019;31(5):e13527.
11. Riby JE, Fujisawa T, Kretchmer N. Fructose absorption. *Am J Clin Nutr*. 1993;58(5)(suppl):748S-753S.
12. Pinto-Sanchez MI, Bercik P, Verdu EF. Motility alterations in celiac disease and non-celiac gluten sensitivity. *Dig Dis*. 2015;33(2):200-207.
13. Volta U, De Giorgio R. New understanding of gluten sensitivity. *Nat Rev Gastroenterol Hepatol*. 2012;9(5):295-299.
14. Biesiekierski JR, Newnham ED, Irving PM, et al. Gluten causes gastrointestinal symptoms in subjects without celiac disease: a double-blind randomized placebo-controlled trial. *Am J Gastroenterol*. 2011;106(3):508-514.
15. Skodje GI, Sarna VK, Minelle IH, et al. Fructan, rather than gluten, induces symptoms in patients with self-reported non-celiac gluten sensitivity. *Gastroenterology*. 2018;154(3):529-539.e2.
16. Biesiekierski JR, Peters SL, Newnham ED, Rosella O, Muir JG, Gibson PR. No effects of gluten in patients with self-reported non-celiac gluten sensitivity after dietary reduction of fermentable, poorly absorbed, short-chain carbohydrates. *Gastroenterology*. 2013;145(2):320-328.e1-3.
17. Staudacher HM, Whelan K, Irving PM, Lomer MC. Comparison of symptom response following advice for a diet low in fermentable carbohydrates (FODMAPs) versus standard dietary advice in patients with irritable bowel syndrome. *J Hum Nutr Diet*. 2011;24(5):487-495.
18. Halmos EP, Power VA, Shepherd SJ, Gibson PR, Muir JG. A diet low in FODMAPs reduces symptoms of irritable bowel syndrome. *Gastroenterology*. 2014;146(1):67-75.e5.
19. Böhn L, Störsrud S, Liljebo T, et al. Diet low in FODMAPs reduces symptoms of irritable bowel syndrome as well as traditional dietary advice: a randomized controlled trial. *Gastroenterology*. 2015;149(6):1399-1407.e2.
20. Black CJ, Staudacher HM, Ford AC. Efficacy of a low FODMAP diet in irritable bowel syndrome: systematic review and network meta-analysis [published online August 10, 2021]. *Gut*. doi:10.1136/gutjnl-2021-325214.
21. Lacy BE, Pimentel M, Brenner DM, et al. ACG Clinical Guideline: management of irritable bowel syndrome. *Am J Gastroenterol*. 2021;116(1):17-44.
22. Rao SSC, Bhagatwala J. Small intestinal bacterial overgrowth: clinical features and therapeutic management. *Clin Transl Gastroenterol*. 2019;10(10):e00078.
23. Cangemi DJ, Lacy BE, Wise J. Diagnosing small intestinal bacterial overgrowth: a comparison of lactulose breath tests to small bowel aspirates. *Dig Dis Sci*. 2021;66(6):2042-2050.
24. Grace E, Shaw C, Whelan K, Andreyev HJ. Review article: small intestinal bacterial overgrowth—prevalence, clinical features, current and developing diagnostic tests, and treatment. *Aliment Pharmacol Ther*. 2013;38(7):674-688.
25. Sharara AI, Aoun E, Abdul-Baki H, Mounzer R, Sidani S, Elhajj I. A randomized double-blind placebo-controlled trial of rifaximin in patients with abdominal bloating and flatulence. *Am J Gastroenterol*. 2006;101(2):326-333.
26. Pimentel M, Lembo A, Chey WD, et al; TARGET Study Group. Rifaximin therapy for patients with irritable bowel syndrome without constipation. *N Engl J Med*. 2011;364(1):22-32.
27. Tan VPY, Liu KSH, Lam FYF, Hung IF, Yuen MF, Leung WK. Randomised clinical trial: rifaximin versus placebo for the treatment of functional dyspepsia. *Aliment Pharmacol Ther*. 2017;45(6):767-776.
28. Bharucha AE, Lacy BE. Mechanisms, evaluation and management of chronic constipation. *Gastroenterology*. 2020;158(5):1232-1249.e3.
29. Johanson JF, Kralstein J. Chronic constipation: a survey of the patient perspective. *Aliment Pharmacol Ther*. 2007;25(5):599-608.
30. Neri L, Iovino P; Laxative Inadequate Relief Survey (LIRS) Group. Bloating is associated with worse quality of life, treatment satisfaction, and treatment responsiveness among patients with constipation-predominant irritable bowel syndrome and functional constipation. *Neurogastroenterol Motil*. 2016;28(4):581-591.
31. Bharucha AE, Wald A. Chronic constipation. *Mayo Clin Proc*. 2019;94(11):2340-2357.
32. Shin A, Preidis GA, Shulman R, Kashyap PC. The gut microbiome in adult and pediatric functional gastrointestinal disorders. *Clin Gastroenterol Hepatol*. 2019;17(2):256-274.
33. Videlock EJ, Lembo A, Cremonini F. Diagnostic testing for dyssynergic defecation in chronic constipation: meta-analysis. *Neurogastroenterol Motil*. 2013;25(6):509-520.
34. Grossi U, Carrington EV, Bharucha AE, Horrocks EJ, Scott SM, Knowles CH. Diagnostic accuracy study of anorectal manometry for diagnosis of dyssynergic defecation. *Gut*. 2016;65(3):447-455.
35. Carrington EV, Scott SM, Bharucha A, et al; International Anorectal Physiology Working Group and the International Working Group for Disorders of Gastrointestinal Motility and Function. Expert consensus document: advances in the evaluation of anorectal function. *Nat Rev Gastroenterol Hepatol*. 2018;15(5):309-323.
36. Shim L, Prott G, Hansen RD, Simmons LE, Kellow JE, Malcolm A. Prolonged balloon expulsion is predictive of abdominal distension in bloating. *Am J Gastroenterol*. 2010;105(4):883-887.
37. Chiarioni G, Salandini L, Whitehead WE. Biofeedback benefits only patients with outlet dysfunction, not patients with isolated slow transit constipation. *Gastroenterology*. 2005;129(1):86-97.
38. Wang J, Luo MH, Qi QH, Dong ZL. Prospective study of biofeedback retraining in patients with chronic idiopathic functional constipation. *World J Gastroenterol*. 2003;9(9):2109-2113.
39. Chiotakakou-Faliakou E, Kamm MA, Roy AJ, Storrie JB, Turner IC. Biofeedback provides long-term benefit for patients with intractable, slow and normal transit constipation. *Gut*. 1998;42(4):517-521.
40. Drossman DA, Chey WD, Johanson JF, et al. Clinical trial: lubiprostone in patients with constipation-associated irritable bowel syndrome—results of two randomized, placebo-controlled studies. *Aliment Pharmacol Ther*. 2009;29(3):329-341.
41. Lembo AJ, Johanson JF, Parkman HP, Rao SS, Miner PB Jr, Ueno R. Long-

term safety and effectiveness of lubiprostone, a chloride channel (ClC-2) activator, in patients with chronic idiopathic constipation. *Dig Dis Sci*. 2011;56(9):2639-2645.
42. Lembo AJ, Schneier HA, Shiff SJ, et al. Two randomized trials of linaclotide for chronic constipation. *N Engl J Med*. 2011;365(6):527-536.
43. Lacy BE, Schey R, Shiff SJ, et al. Linaclotide in chronic idiopathic constipation patients with moderate to severe abdominal bloating: a randomized, controlled trial. *PLoS One*. 2015;10(7):e0134349.
44. Chey WD, Lembo AJ, Lavins BJ, et al. Linaclotide for irritable bowel syndrome with constipation: a 26-week, randomized, double-blind, placebo-controlled trial to evaluate efficacy and safety. *Am J Gastroenterol*. 2012;107(11):1702-1712.
45. Miner PB Jr, Koltun WD, Wiener GJ, et al. A randomized phase III clinical trial of plecanatide, a uroguanylin analog, in patients with chronic idiopathic constipation. *Am J Gastroenterol*. 2017;112(4):613-621.
46. Brenner DM, Fogel R, Dorn SD, et al. Efficacy, safety, and tolerability of plecanatide in patients with irritable bowel syndrome with constipation: results of two phase 3 randomized clinical trials. *Am J Gastroenterol*. 2018;113(5):735-745.
47. Nelson AD, Black CJ, Houghton LA, Lugo-Fagundo NS, Lacy BE, Ford AC. Systematic review and network meta-analysis: efficacy of licensed drugs for abdominal bloating in irritable bowel syndrome with constipation. *Aliment Pharmacol Ther*. 2021;54(2):98-108.
48. Agrawal A, Houghton LA, Lea R, Morris J, Reilly B, Whorwell PJ. Bloating and distention in irritable bowel syndrome: the role of visceral sensation. *Gastroenterology*. 2008;134(7):1882-1889.
49. Zhu Y, Zheng X, Cong Y, et al. Bloating and distention in irritable bowel syndrome: the role of gas production and visceral sensation after lactose ingestion in a population with lactase deficiency. *Am J Gastroenterol*. 2013;108(9):1516-1525.
50. Farré R, Vanheel H, Vanuytsel T, et al. In functional dyspepsia, hypersensitivity to postprandial distention correlates with meal-related symptom severity. *Gastroenterology*. 2013;145(3):566-573.
51. Talley NJ, Locke GR, Saito YA, et al. Effect of amitriptyline and escitalopram on functional dyspepsia: a multicenter, randomized controlled study. *Gastroenterology*. 2015;149(2):340-349.e2.
52. Tack J, Janssen P, Masaoka T, Farré R, Van Oudenhove L. Efficacy of buspirone, a fundus-relaxing drug, in patients with functional dyspepsia. *Clin Gastroenterol Hepatol*. 2012;10(11):1239-1245.
53. Tack J, Broekaert D, Fischler B, Van Oudenhove L, Gevers AM, Janssens J. A controlled crossover study of the selective serotonin reuptake inhibitor citalopram in irritable bowel syndrome. *Gut*. 2006;55(8):1095-1103.
54. Saito YA, Almazar AE, Tilkes KE, et al. Randomised clinical trial: pregabalin vs placebo for irritable bowel syndrome. *Aliment Pharmacol Ther*. 2019;49(4):389-397.
55. Palsson OS, Ballou S. Hypnosis and cognitive behavioral therapies for the management of gastrointestinal disorders. *Curr Gastroenterol Rep*. 2020;22(7):31.
56. Vasant DH, Whorwell PJ. Gut-focused hypnotherapy for functional gastrointestinal disorders: evidence-base, practical aspects, and the Manchester Protocol. *Neurogastroenterol Motil*. 2019;31(8):e13573.
57. Villoria A, Azpiroz F, Burri E, Cisternas D, Soldevilla A, Malagelada JR. Abdomino-phrenic dyssynergia in patients with abdominal bloating and distension. *Am J Gastroenterol*. 2011;106(5):815-819.
58. Accarino A, Perez F, Azpiroz F, Quiroga S, Malagelada JR. Abdominal distention results from caudo-ventral redistribution of contents. *Gastroenterology*. 2009;136(5):1544-1551.
59. Burri E, Barba E, Huaman JW, et al. Mechanisms of postprandial abdominal bloating and distension in functional dyspepsia. *Gut*. 2014;63(3):395-400.
60. Barba E, Burri E, Accarino A, et al. Abdominothoracic mechanisms of functional abdominal distension and correction by biofeedback. *Gastroenterology*. 2015;148(4):732-739.
61. Barba E, Accarino A, Azpiroz F. Correction of abdominal distension by biofeedback-guided control of abdominothoracic muscular activity in a randomized, placebo-controlled trial. *Clin Gastroenterol Hepatol*. 2017;15(12):1922-1929.
62. Foley A, Burgell R, Barrett JS, Gibson PR. Management strategies for abdominal bloating and distension. *Gastroenterol Hepatol (N Y)*. 2014;10(9):561-571.
63. Lacy BE, Cangemi D, Vazquez-Roque M. Management of chronic abdominal distension and bloating. *Clin Gastroenterol Hepatol*. 2021;19(2):219-231.e1.