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Title: Symptom Severity and Clinical Characteristics of Patients with Bloating

Running Title: Clinical Characteristics of Patients with Bloating

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Abstract

Background

Abdominal bloating is common in functional gastrointestinal disorders (FGID). To better characterize this patient population, we evaluated clinical and psychological characteristics of bloating and analyzed their differences by bloating severity.

Methods

Patients with FGIDs evaluated at a single academic outpatient referral gastroenterology clinic were surveyed. Bloating severity was classified as minimal, moderate or severe. Symptom-specific questionnaires were used to evaluate bowel habits, abdominal bloating, depression, anxiety, somatization and sleep disturbance. Associations between bloating severity, clinical characteristics and FGID subtypes were analyzed in univariate and multivariate modeling.

Key Results

Of 612 FGID patients included (78% female, mean age of 44 ± 16.5 years), bloating was reported as minimal in 231(37.8%), moderate in 217(35.4%), or severe in 164(26.8%). Patients with severe bloating were more likely to be female, younger, and have co-existing functional dyspepsia than those with minimal bloating ($p < 0.05$). Bloating severity and severity of abdominal distension were significantly correlated ($p < 0.05$). On multivariable regression, patients who met criteria for functional constipation and functional dyspepsia had 80% and 125% higher odds, respectively, of severe bloating compared to minimal to moderate bloating. Younger age, abdominal pain and constipation severity, and somatization scores were also independently associated with severity of bloating.

Conclusions & Inferences

Severe bloating is associated with younger age, and with more severe abdominal pain, constipation, and somatization. Patients who met criteria for functional constipation and functional dyspepsia are more likely to experience severe bloating.

Keywords: Functional gastrointestinal disorders, irritable bowel syndrome, functional dyspepsia, constipation, bloating

Introduction

Abdominal bloating is a subjective sensation of abdominal fullness, pressure, or a sense of gassiness with or without abdominal distension¹. Bloating is common, with a prevalence of up to 16% of the adult population, and even higher in women, up to 20%². Up to 70% of patients with functional gastrointestinal disorders (FGID) report bloating, and many identify bloating as their predominant or most bothersome symptom³. Overall, bloating can have a significant impact on quality of life, energy level, physical functioning, and healthcare utilization^{2,4}.

Many studies have examined the presence or absence of bloating^{4,5}, but few have investigated bloating severity⁶. Hod et al. investigated the association between bloating severity, other GI symptoms, and psychological distress in patients with IBS⁶. In this study, bloating severity correlated with IBS symptom severity, pain severity, and both anxiety and somatization scores. Since this study was limited to IBS it cannot be generalized to other FGIDs⁶.

The primary aim of this study is to evaluate the clinical and psychological characteristics of all patients who report bloating regardless of their underlying diagnosis in a large cohort of FGID patients, and stratify patients by bloating severity to better characterize this patient population. This analysis will help illuminate key characteristics of patients with bloating to gain insight into the patient population experiencing severe bloating.

Materials and Methods

Patients

Patients presenting to the outpatient Center for Functional Bowel Disorders and GI Motility at Beth Israel Deaconess Medical Center in Boston, Massachusetts between October 2017 and March 2020 completed an electronic symptom survey at their initial visit. Data was collected via Research Electronic Data Capture (REDCap), a HIPAA compliant, free, secure, web-based application. Ethics approval was obtained from the institutional review board. Patients were considered eligible if they were clinically diagnosed with a functional gastrointestinal disorder (IBS, functional dyspepsia (FD), functional constipation (FC), functional diarrhea, functional abdominal pain or pelvic floor dyssynergia), and they were not found to have an alternative organic cause for their symptoms within 6 months of their initial visit (based on review of online medical records).

Questionnaires

Rome IV. Patients were administered the Rome IV questionnaire for FD, IBS, functional constipation and functional diarrhea. The Rome IV criteria define FD as any combination of 4 symptoms: postprandial fullness, early satiety, epigastric pain, and epigastric burning that are severe enough to interfere with the usual activities⁷. The symptoms should occur at least 3 days per week (for postprandial fullness and early satiety) or once a week (for epigastric pain or burning) over the last 3 months with an onset of at least 6 months in advance⁷. The Rome IV criteria define IBS as recurrent abdominal pain on average at least once per week in the last 3 months, associated with at least two of the following criteria: related to defecation, associated with a change in stool frequency, or associated with a change in stool form⁸. The Rome IV criteria define functional constipation as a disorder in which difficult, infrequent or incomplete defecation predominate; these patients do not meet IBS criteria but may have symptoms such as abdominal pain and/or bloating⁸. Functional diarrhea is defined by the Rome IV criteria as recurrent passage of loose or watery stools, not meeting IBS criteria, but may have non-predominant symptoms of abdominal pain and/or bloating⁸. For all four diagnoses, diagnostic criteria must be fulfilled for the last 3 months with symptom onset at least 6 months prior to diagnosis⁸.

Bloating and Distension

Severity of the bloating was assessed by asking patients to “Please rate the severity of your bloating in the last 2 weeks” and patients were asked to choose one of the six responses – “none”, “very mild bloating”, “mild bloating”, “moderate bloating”, “severe bloating” and “very severe bloating”. Based on this, we grouped severity responses into three groups: minimal bloating (those responding as “none” or “very mild bloating”) moderate bloating (those responding to “mild bloating” or “moderate bloating”) and severe bloating (“severe bloating” or “very severe bloating”). Severity of abdominal distension was measured by asking patients to “Please rate the severity to which your stomach or belly has been visually larger” and patients chose between the same six responses, “none”, “very mild”, “mild”, “moderate”, “severe”, or “very severe”. Responses were grouped into three severity categories, mirroring the severity groups of bloating.

Patient Reported Outcomes Measurement Information System (PROMIS) scales. Patients completed the PROMIS Abdominal pain, constipation, diarrhea, Anxiety 7a, Depression 8a, and

Sleep Disturbance 6a questionnaires before their initial visit. For each PROMIS questionnaire, the total raw score was calculated by summing the response to each question, which was then transformed to standardized T-score. The PROMIS scales have been validated to correlate with patient symptoms⁹.

Patient Health Questionnaire 12 Somatic Symptom Scale (PHQ-12). The PHQ-12 is a validated tool to measure somatization and refers to the responses of 12 questions in PHQ-15 which relates to non-gastrointestinal symptoms. Patients are asked about the bothersomeness of each symptom, where 0 = not bothered at all, 1 = bothered a little, and 2 = bothered a lot, and the symptom burden is measured by the sum of the scores of all symptoms¹⁰.

Statistical Analysis

Statistical analysis was performed using Stata 13.0 (Statacorp, College Station, TX, USA). Descriptive statistics such as mean with standard deviation (SD) and median with interquartile range (IQR) are reported. Baseline demographic and clinical characteristics were compared among the three bloating severity groups (minimal bloating, moderate bloating and severe bloating) using ANOVA. Post-hoc analyses using Bonferroni correction were performed when P-value for ANOVA was significant (i.e. <0.05). Chi-square tests were performed for sub-analyses, including comparing bloating severity by IBS subtype and by severity of abdominal distension.

For the multivariable ordered logistic regression, dependent or outcome variable was bloating severity with three groups of severity as above-minimal, moderate and severe. Independent variables include following continuous variables (age, severity of abdominal pain, constipation, diarrhea, anxiety, depression and sleep disturbance using PROMIS T-scores) and categorical variables (gender, Rome IV diagnoses of IBS, functional dyspepsia, functional constipation and functional diarrhea). P-value <0.05 was considered significant for multivariable ordered logistic regression.

Results

Patient Population

Of 922 patients who established care at our outpatient Center for Functional Bowel Disorders and Gastrointestinal Motility during the study period, 612 patients were diagnosed with a FGID and completed the questions on bloating (Figure 1). 604 patients completed

questions on both bloating and abdominal distension. The demographics, clinical characteristics and FGID diagnoses of the 612 patients included for further analysis are shown in Table 1.

Of these 612 patients with clinically diagnosed functional gastrointestinal disorders, 467 (76.3%) patients met at least one of the four ROME IV criteria (IBS, functional diarrhea, functional constipation and functional dyspepsia) (Table 1). The majority of functional dyspepsia patients diagnosed by Rome IV criteria (n=193) had concurrent Rome IV diagnoses of IBS (44.3%), functional constipation (11.5%) or functional diarrhea (7.5%). The remaining 145 patients (23.7%) were clinically diagnosed with a functional gastrointestinal disorder (e.g. IBS, functional constipation, functional dyspepsia, functional diarrhea, functional abdominal pain, pelvic floor dyssynergia) but did not meet Rome IV criteria by questionnaire.

Of 612 patients, 231(37.8%) reported minimal bloating, 217 (35.4%) moderate bloating, and 164 (26.8%) severe bloating (Table 1). Bloating severity significantly correlated with severity of abdominal distension and up to 92.5% of patients with severe distention also had severe bloating (Table 2). The proportion of women reporting bloating increased with increases in bloating severity (Table 3). The mean age of patients reporting severe bloating (41 ± 15.5 years) was significantly lower compared to those reporting minimal bloating (46.8 ± 16.6 years, Bonferroni adjusted $P=0.002$).

Gastrointestinal and bowel symptoms

The proportion of patients meeting the ROME IV criteria for FD increased with severity of bloating ($P<0.001$) and 72% of patients reporting severe bloating had FD compared to 29% who reported minimal bloating (Table 3). Percentage of patients meeting criteria for IBS, FC and functional diarrhea were similar across bloating severity categories. IBS with constipation was more likely to be associated with severe bloating than IBS with diarrhea ($p=0.03$, Table 3). There was no difference in bloating severity between those patients who had multiple FGIDs (i.e. IBS and functional dyspepsia) and those with functional dyspepsia or IBS alone ($p=0.5$, data not shown).

The severity of constipation, severity of abdominal pain, and somatization scores were significantly different among the three bloating severity categories ($P<0.001$ for all). In Bonferroni post-hoc comparison, patients with severe bloating had greater mean PROMIS constipation t-score, greater mean PROMIS abdominal pain t-score, and greater somatization

score (PHQ-12) compared to those reporting minimal bloating and moderate bloating symptoms (Table 3). There were no differences seen in PROMIS diarrhea t-scores across bloating severity categories.

We also found that severity of constipation correlated with severity of bloating (OR 1.06, 95% CI 1.04, 1.08, $P < 0.001$) and severity of abdominal distention (OR 1.05, 95% CI 1.03, 1.07, $P < 0.001$) on ordered logistic regression. Even after adjusting for severity of abdominal distention, severity of constipation continued to be significantly associated with severity of bloating (OR 1.05, 95% CI 1.02, 1.07, $P < 0.001$) on ordered logistic regression.

Psychosocial characteristics

Severity of anxiety, depression, sleep disturbance, and somatization were significantly greater in those reporting severe bloating compared to those reporting minimal bloating (Bonferroni adjusted $P < 0.001$ for each).

Multivariable regression

On multivariable regression, abdominal pain severity, constipation severity, presence of Rome IV functional constipation or functional dyspepsia, and somatization scores were independently positively associated with severity of bloating (Table 4).

Discussion

In this large cohort of patients with functional gastrointestinal disorders, 85% of patients reported at least some degree of bloating and more than a quarter of these patients reported severe or very severe bloating. We found that constipation severity, abdominal pain severity, somatization severity, and the diagnoses of functional dyspepsia or functional constipation were independently positively associated with severe bloating. Furthermore, severity of anxiety, depression or sleep disturbance were not associated with bloating severity on multivariable analysis.

Our study approaches bloating in FGID patients from the symptom severity perspective, without predefining a FGID diagnosis. Ours is one of the few studies to consider the clinical characteristics associated with bloating severity, including how bloating relates to FGID diagnosis. Our findings suggest that more severe bloating is associated with functional dyspepsia rather than IBS. Previous studies have found bloating to be more predictive of IBS than

functional dyspepsia⁵ although it was significantly associated with both¹¹. However, these studies used ROME III criteria and assessed only for presence of bloating while we used ROME IV criteria and assessed for severity of bloating.

Studies have shown that younger patients are more likely to experience bloating⁵. Our study builds upon this knowledge, and we found as age increased, severity of bloating decreased. Visceral hypersensitivity is one possible pathophysiologic mechanisms of bloating^{12,13} and younger age has been positively associated with visceral hypersensitivity^{14,15}. In our study, severity of bloating was also significantly associated with severity of abdominal pain even after adjusting for other confounding variables. As abdominal pain in FGIDs is thought to be in part mediated by visceral hypersensitivity, it is possible that abdominal pain and bloating share common pathophysiologic mechanisms. Although we did not measure visceral hypersensitivity, it may explain our association of bloating severity with younger age and abdominal pain.

Our study showed severity of constipation to be an independent predictor of bloating severity, and more severe bloating to be associated with constipation predominant conditions such as IBS-C and functional constipation. In fact, with the diagnosis of functional constipation, the odds of reporting severe bloating were 80% higher versus minimal and moderate bloating. Prior studies have shown that patients with constipation are more likely to report bloating compared to those with diarrhea, however, these studies did not report data on association of severity of constipation with severity of bloating^{4,6,11,16-19}. Treating constipation with laxatives or pelvic floor biofeedback, depending on underlying pathophysiology, has been shown to improve bloating²⁰⁻²². In patients with severe or refractory bloating, it is important to evaluate for slow transit constipation and rectal evacuation disorder. Hypoactive gut propulsion and ineffective expulsion of rectal gas have both been shown to increase total gas volume after infusion of IV glucagon or self-restrained anal evacuation, respectively, but only obstructive evacuation induced symptomatic bloating²³. Further research is needed to elucidate the underlying mechanism that links bloating and constipation.

In our study, 72% of patients with severe bloating had functional dyspepsia, which supports the previous findings that functional dyspepsia was associated with presence of bloating⁵. Furthermore, we found that with the diagnosis of functional dyspepsia, the odds of reporting severe bloating were 125% higher versus minimal to moderate bloating. Of note,

diagnosis of post-prandial distress syndrome subtype of bloating requires patients to have significant post-prandial fullness which can also be perceived as bloating. Furthermore, the pathophysiology of bloating in functional dyspepsia is poorly understood but the possible mechanisms include decreased gastric accommodation^{24,25}, visceral hypersensitivity to food^{26,27}, upper gut dysbiosis seen in a subset of functional dyspepsia patients^{28,29}, and gastroduodenal dysmotility^{30,31}. Functional dyspepsia tends to co-exist with chronic constipation and dyspeptic symptoms have been shown to improve in response to treatment for constipation^{21,32,33}.

While the aim of our study was to focus on the sensation of bloating, prior studies demonstrate subsets of patients with the sensation of bloating along with or without visible distension^{17,34}. While the sensation of bloating may be due to heightened visceral hypersensitivity, the pathophysiology of visible distension may be distinct. In our cohort of patients, there is a significant correlation between bloating severity and severity of abdominal distension, both of which also independently correlated with severity of constipation. Interestingly we found that once adjusted for distension severity, more severe constipation still correlated with more severe bloating in this cohort. This suggests that constipation is a possible underlying etiology for abdominal distension as well as bloating in a subset of patients with FGIDs. While initial research has already identified a distinct pathophysiologic pathway for abdominal distension, further research needs to be done to understand the shared as well as distinct pathophysiologic pathways determining bloating and abdominal distension in patients with FGIDs.

We found that bloating severity was associated with depression, anxiety and sleep disturbance on univariable analysis, but these psychological factors were not independently associated with bloating severity on multivariable analysis. There was a significant association between somatization severity and bloating severity on univariable as well as multivariable regression, which is consistent with a previous study that postulated that bloating may be a symptom of somatization (Jiang et al 2008). Prior studies link anxiety, depression and sleep with bloating in patients with FGIDs³⁶⁻³⁸, but our results suggest that worsening bloating is not associated with more severe mental health symptoms. The lack of independent association between depression, anxiety, sleep and bloating severity likely reflects that these mental health symptoms are more strongly associated with symptoms that are often comorbid with bloating, such as abdominal pain and constipation.

Our study has multiple strengths that significantly contribute to the bloating literature. This study is the first to stratify patients by severity of bloating, including mild, moderate and severe, and to include a detailed analysis of these patients' comorbidities, including mental health disorders, sleep disturbance and somatization. The patient population is large, with more than 600 FGID patients reporting bloating severity. Further, this study examines patients through the symptom lens of bloating rather than by an FGID diagnosis. When ultimately stratified by diagnosis, each patient's diagnosis has been well characterized by experts in gastrointestinal motility at a tertiary care academic medical center. However, sourcing patients from a single tertiary care center is one limitation that limits generalizability. The study also does not include analyses comparing the severity of abdominal distension to the outcome variables of interest because bloating and abdominal distension were highly correlated in our cohort. Additionally, abdominal distension was not/could not be measured, and a 'subjective recall' of distension might mirror the patients perception of the severity of their bloating, which if distension had actually been objectively measured might not be the case, as least in some patients or subgroups. Finally, this study does not have data on reported dietary changes or food sensitivities.

In conclusion, bloating is an extremely common symptom in patients with FGIDs, particularly those with functional dyspepsia or constipation. Severe bloating is associated with younger age, and these patients are more likely to present with more severe abdominal pain, constipation, and somatization.

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Author Contribution: PS, JI, and AL conceptualized the study. Data collection and extraction was performed by RH, SB, PS, AL, JI, JN, and CG, and statistical analysis was done by PS. Manuscript was drafted by PS and CG. SB, JI, AL, JN, RH and PS critically revised the manuscript for important intellectual content.

The data that support the findings of this study are available on request from the corresponding author. The data are not publicly available due to privacy or ethical restrictions.

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Demographic characteristics

Mean age (SD)	44.1 (16.5)
Female (% Total)	479 (78.3%)

Functional gastrointestinal disorder subtype[†]	N (%)
Functional dyspepsia [§]	305 (49.8%)
Irritable bowel syndrome	212 (34.6%)
Functional constipation	78 (12.8%)
Functional diarrhea	65 (10.6%)
FGID not meeting Rome IV criteria by questionnaire	145 (23.7%)

Clinical characteristic severity, T-score[‡]	Mean (SD)
Abdominal pain	59.2 (11)
Constipation	54.2 (9)
Diarrhea	52.7 (10.1)
Anxiety	55.5 (9.9)

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Table 1: Demographic and clinical characteristics of study population (n=612)

Depression	49.4 (9.8)
Sleep disturbance	53.4 (9.0)
PHQ-12 score	6.7 (3.9)

<i>Bloating severity</i>	N (%)	
Minimal bloating	231 (37.7%)	
	No bloating	15.0%
	Not very severe	22.7%
Moderate bloating	217 (35.4%)	
	Somewhat severe	21.2%
	Severe	14.2%
Severe bloating	164 (26.8%)	
	Quite severe	13.1%
	Very severe	13.7%

† Met Rome IV criteria by questionnaire

‡ Characteristics measured using PROMIS T scores

§Of 305 patients, 193 also met criteria for another FGID.

Table 2: Patients stratified by bloating severity vs. severity of abdominal distension (N=604, p<0.001 by chi-square test)

Minimal bloating N=229	Moderate bloating N=213	Severe bloating N=162	Total
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Minimal distension[†]	219 (63.1)	105 (30.2)	23 (6.6)	347 (100)
Moderate distension[†]	10 (6.6)	100 (66.2)	41 (27.1)	151 (100)
Severe distension[†]	0 (0)	8 (7.5)	98 (92.4)	106 (100)

[†] Fields reported as number of study participants (% of total distension severity group)

Table 3: Distribution of demographic, gastrointestinal and psychosomatic characteristics by severity of bloating

	Minimal bloating n=231	Moderate bloating n=217	Severe bloating n=164	P-value[†]
Age [‡]	46.8 (16.6)	43.6 (16.7)	41 (15.5)	0.002
Female sex [‡]	168 (72.7)	172 (79.3)	139 (84.8)	0.015
FGID subtype[‡]				
Functional dyspepsia	67 (29)	120 (55.3)	118 (72)	<0.001
IBS	69 (29.9)	80 (36.9)	63 (38.4)	0.15
Functional constipation	23 (10.0)	27 (12.4)	28 (17.1)	0.11
Functional diarrhea	24 (10.4)	23 (10.6)	18 (11.0)	0.98
IBS subtype[§]				0.03
IBS constipation	9 (20)	20 (44.4)	16 (35.5)	
IBS diarrhea	31 (43.6)	22 (31)	18 (25)	
Severity of gastrointestinal symptoms (PROMIS T-score) *				
Abdominal pain	53.4 (11.8)	60.4 (8.3)	65.8 (8.2)	<0.001
Constipation	51.3 (8.5)	54.8 (8.5)	57.5 (9.0)	<0.001

Diarrhea	51.7 (9.9)	53.1 (10.0)	53.7 (10.5)	0.12
Anxiety	53.5 (9.4)	55.6 (9.7)	58.0 (10.5)	<0.001
Depression	47.5 (8.9)	49.5 (9.4)	51.9 (10.9)	<0.001
Sleep disturbance	51.8 (8.4)	52.7 (8.7)	56.5 (9.4)	<0.001
PHQ-12 Score*	5.3 (3.3)	6.9 (3.8)	8.3 (4.3)	<0.001

†Differences reported compare minimal vs. moderate vs. severe bloating, detected by ANOVA analysis, except IBS subtype for which a chi-square test was performed

‡ Fields reported as number of study participants (% of total bloating severity group)

§ Fields reported as number of study participants (% of total IBS subtype group)

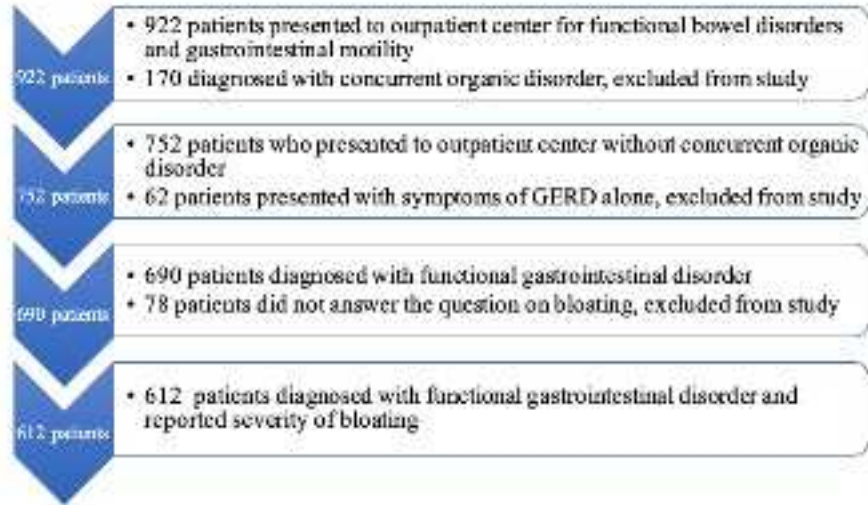
*Reported as mean score (SD)

Table 4: Multivariable ordinal logistic regression comparing minimal, moderate, and severe bloating

	Odds Ratio, 95% CI [LL,UL]	p value
Age	-0.99 [-0.98, 0.99]	0.041
Sex	1.22 [0.81, 1.84]	0.336
<i>FGID subtype</i>		
IBS	0.65 [0.43, 0.98]	0.039
Functional dyspepsia	2.24 [1.58, 3.18]	<0.001

Functional constipation	1.8 [1.06, 3.07]	0.031
<i>Severity of gastrointestinal symptoms (PROMIS T-score)</i>		
Abdominal pain	1.08 [1.06, 1.10]	<0.001
Constipation	1.04 [1.02, 1.06]	<0.001
Diarrhea	0.99 [0.97, 1.01]	0.308
Anxiety	1.00 [0.97, 1.02]	0.885
Depression	1.00 [0.98, 1.03]	0.858
Sleep disturbance	0.99 [0.97,1.01]	0.397
PHQ-12 Score	1.08 [1.02,1.14]	0.005

Figure 1. Patient population included in study



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