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Systematic Review and Meta-analysis

Prevalence and severity of abdominal bloating in patients with gastroesophageal reflux disease

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SUMMARY. **Abdominal bloating (AB) is a common symptom among patients with gastroesophageal reflux disease (GERD); however, in clinical practice, its prevalence is likely underestimated due to the lack of objective tools to measure its frequency and severity. It is associated with dissatisfaction and worse quality of life, but data on its prevalence before and after mechanical control of GERD (i.e. fundoplication, magnetic sphincter augmentation, and antireflux mucosectomy) are lacking. To assess and determine the pre- and postoperative prevalence and severity of AB among patients with GERD, we conducted a structured literature search using MeSH and free-text terms in MEDLINE (via Pubmed), EMBASE, and Taylor & Francis Online between January 1977 and October 2022. Fifteen articles reporting the prevalence or severity of AB using quality-of-life questionnaires before or after antireflux surgery (ARS) were included. Overall, a high prevalence of AB before ARS was found. A decline in the prevalence and severity of AB was documented postoperatively in most cases independent of the surgical approach. Among surgical approaches, a complete fundoplication had the highest reported postoperative AB. Overall, patients reported less severe and less frequent AB after ARS than before. The traditional belief that postoperative bloating is a sequela of ARS should be reevaluated.**

KEY WORDS: **digestive system surgical procedures, fundoplication, gas bloat syndrome, gastroesophageal reflux, GERD, magnetic sphincter augmentation.**

BACKGROUND

Gastroesophageal reflux and abdominal bloating

Gastroesophageal reflux disease (GERD) is an increasingly prevalent chronic gastrointestinal disease that affects between 18% and 28% of Americans.[1,2] Abdominal bloating (AB), defined as the subjective sensation of trapped gas in the upper abdomen accompanied by increased abdominal pressure,[3–5] is commonly reported by patients with GERD. It has been associated with significantly lower patient quality of life (QoL).[6,7] Causes of AB include irritable bowel syndrome, carbohydrate malabsorption, altered gut microbiota, and functional dyspepsia.[3,6]

Historically, it has been proposed that gastroesophageal reflux arises from an incompetent lower esophageal sphincter (LES) barrier and transient LES relaxation (TLESR). During TLESR, the LES temporarily relaxes independent of deglutition; the temporary relaxation may be further exacerbated by increased intra-abdominal pressure.[8,9] Patients suffering from GERD generally exhibit dysfunction of the LES, leading to increased or prolonged TLESR and increased aerophagia.[10,11]

Gastric distension, whether physiologic or pathologic, stimulates TLESR, which leads to an increase in reflux events and subsequent aerophagia.[12,13] This may create a positive feedback loop in which TLESR stimulates aerophagia, resulting in gastric distension, which again stimulates TLESR.[13] Such a feedback loop may exacerbate the psychological impetus for aerophagia; reflux perception has been shown to elicit increased swallowing.[10,13,14] This may also explain increased postprandial gastroesophageal reflux, as reflux can increase four to seven times postprandially in patients with GERD, presumably as the result of increased gastric distension.[15]

In severe cases of GERD, antireflux surgery (ARS) can be performed to reduce the severity and longitudinal impact of gastroesophageal reflux; however,

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AB has also been reported as a common undesirable sequela of ARS.[16] The inability to completely relax the LES after fundoplication may be to blame.[17] Although this incomplete relaxation decreases gastroesophageal reflux, it may concomitantly lead to an inability to belch.[18]

AB is a subjective symptom with poor objective assessment options; hence, it is difficult to determine the frequency and severity in the general population and in patients with GERD. AB can be objectively measured by abdominal girth, but studies have shown that patient-reported AB is frequently not associated with measurable changes in abdominal distension.[19] In clinical practice, GERD is generally assessed with GERD-specific QoL questionnaires, although they are not specific or sensitive for evaluating AB; however, a few studies have specifically measured AB, reporting that it is common among patients with GERD even before ARS. In 2001, Rothman et al.[20] documented a prevalence of 60.1% of bloating among patients with GERD using the Gastrointestinal Symptom Rating Scale. In 2009, Watson et al.[21] found that 48.2% of patients with GERD reported bloating, with 12.8% reporting bloating several times a week. Importantly, the overlap of AB with other conditions, such as epigastric pain, flatulence, or intestinal symbiosis, has been reported.[22,23] Therefore, a careful interpretation of the data is recommended since the reporting of AB does not mean that GERD is the only underlying cause. For example, Rentz et al.[23] documented a moderate correlation between heartburn, regurgitation, and upper abdominal pain with bloating, while Haworth et al.[22] found that patients with GERD with intestinal dysbiosis were more likely to report bloating before ARS.

This structured narrative literature review aims to provide an updated summary of the evidence on the prevalence and severity of AB as a symptom in patients with GERD and the differences in postoperative AB severity between various antireflux surgical approaches.

METHODS

A literature search for this structured narrative review was done using primary databases, including Medline (via PubMed), EMBASE, and Taylor & Francis; no ancillary searches were performed. An automated search strategy was implemented using structured basic search algorithms, including a comprehensive list of MeSH terms (e.g. gastroesophageal reflux, gastric acid reflux, GERD, and gas bloat syndrome) and non-MeSH terms (e.g. AB and bloating). The period covered was January 1977 to October 2022, and the results were limited by language to English or Spanish. We included case reports with literature reviews, case series, retrospective and prospective observational studies, cross-sectional studies, randomized clinical trials, systematic literature reviews, and meta-analyses.

Using a conventional blinded system, two authors (ARL-R, MS) screened the title and abstract of the search results to find relevant studies to support the review's aim; the full text of selected articles was retrieved and verified for relevance. Search results were tabulated, and the information was extracted using a secure spreadsheet (Google, Mountain View, CA). The PRISMA-2020 checklist was used as a guide to examine the manuscript.

RESULTS

A total of 18 articles documenting the prevalence or severity of AB using QoL questionnaires before or after ARS were identified and retrieved using the previously described search strategy; 3 of these articles were excluded: 2 were excluded because they compared the outcomes of patients who underwent ARS with the outcomes of patients treated with proton pump inhibitors; and 1 was excluded because the specific study population suffered from depressive disorders. Of the remaining articles, six retrospective and four prospective observational studies, three meta-analyses, and two randomized controlled trials (RCTs) were included in the review. Figure 1 presents the PRISMA flowchart of the search results.

Prevalence of AB among patients with GERD before and after ARS

Mechanical control of GERD can be achieved by several surgical approaches, including a Dor fundoplication (DF), Toupet fundoplication (TF), and Nissen fundoplication (NF) as well as magnetic sphincter augmentation (MSA), transoral incisionless fundoplication, and antireflux mucosectomy (ARMS). However, one of the most commonly reported undesirable sequelae of ARS is the inability to belch, purportedly leading to the accumulation of swallowed air, which may present clinically as AB.[24]

There is a surprising paucity of studies reporting both pre- and postoperative bloating in patients undergoing ARS. A study by Ganz et al. reported an AB prevalence of 52% and 8.3% before and after ARS (MSA), respectively.[25] Another study reviewed a national registry of patients who underwent NF, DF, or TF and reported a post-ARS AB prevalence of 23.2%.[26] Furthermore, we identified two studies in which the prevalence of postoperative AB between TF and NF was compared. In 2010, Shan et al.[27] conducted a meta-analysis of 32 NF and TF trials ($n = 1219$), finding that postoperative AB was reported by 47.4% (327/690) of patients who underwent NF and 26.1% (138/529) of those

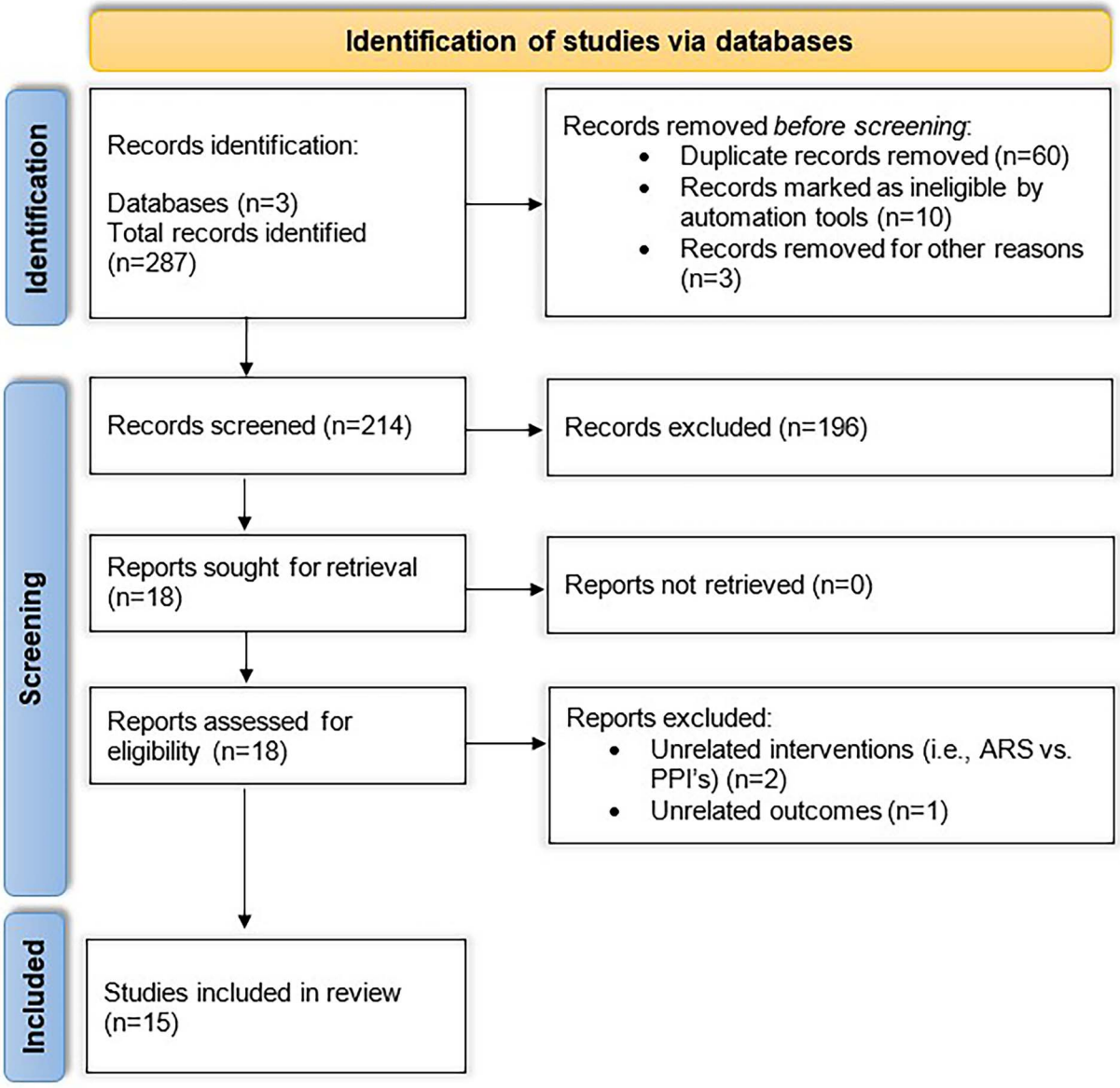

Fig. 1 PRISMA flow diagram of search results.

who underwent TF ($P = 0.002$). Toydemir et al.[28] noted similar results in their prospective study of 1000 patients; 19.6% of patients who underwent NF ($n = 684$) reported postoperative AB compared to 10.8% ($n = 316$) of those who underwent TF ($P = 0.001$).

The effectiveness of alternative fundoplication approaches relative to NF was considered in two publications. Watson et al.[29] conducted a single-center RCT comparing anterior 90° partial fundoplication and NF; at 5 years of follow-up of 74 patients, patient-reported AB was significantly higher in the NF group (32.4% vs. 80.0%, $P < 0.01$). Moreover, Broeders et al.[30] compared clinical outcomes between DF and NF in a meta-analysis, including a total of 458 patients; the authors found that postoperative AB occurred in 11% of patients who underwent DF and 18% of those who underwent NF.

By the same token, three studies compared MSA to NF or TF. In 2015, Riegler et al. conducted a prospective, multicenter study of 249 patients undergoing these operations.[31] Using the GERD-Health Related Quality of Life (GERD-HRQL) questionnaire, the authors found that at 1 year excessive gas and AB were reported by only 10% of patients after MSA ($n = 202$) compared to 31.9% after NF or TF ($n = 47$, $P < 0.001$). These findings were consistent with a retrospective cohort study by Warren et al.[32] At 1 year, 27% of patients who underwent MSA reported mild postoperative AB compared to 40% of those who underwent NF ($P = 0.03$). The largest of these studies was a meta-analysis by Skubleny et al.[33] that

compared MSA and NF at 1 year across three studies, including a total of 627 patients.[33] Postoperative AB prevalence was nearly twofold higher after NF (53.4%) than after MSA (26.7%), but this difference was not statistically significant ($P = 0.06$). However, none of these studies are randomized trials, and there are no data regarding the prevalence of preoperative AB bloating.

Does the ARS approach change AB and related QoL?

The severity of AB following ARS has been compared using QoL scores in seven studies, including one randomized controlled clinical trial, five retrospective studies, and one prospective observational study. Papasavas et al.[34] were the first authors to quantify and assess the severity of pre- and postoperative AB using a 10-point visual analog scale. This gas/bloat score was used to divide patients into two groups: those without significant preoperative aerophagia (score < 3) ($n = 129$) and those with significant preoperative aerophagia (score > 3; $n = 210$). Patients in both groups underwent either NF ($n = 278$) or TF ($n = 61$). At the 2-year follow-up, the group with less preoperative aerophagia reported significantly increased bloating (mean: 1.2 to 3.8, $P < 0.01$), whereas the group with a preoperative score >3 reported significantly decreased bloating (mean: 7.7 to 4.8, $P < 0.01$). Of note, both groups of patients reported a similar AB severity after surgery (mean: 3.8 vs. 4.8).

Differences in the postoperative severity of AB after NF or TF were evaluated in a RCT of 125 patients conducted by Koch et al.[35] using the Gastrointestinal Quality of Life Index (GIQLI) to measure both pre- and postoperative AB severity at the 1-year follow-up. The NF group ($n = 62$) had a median reduction of 45% (11.6 to 6.43 points), and the TF group ($n = 63$) had a reduction of 42% (9.32 to 5.43 points); both reductions were statistically significant and comparable between interventions.

Later, Louie et al.[36] conducted a retrospective observational study of 66 patients. The postoperative AB severity was assessed using the GERD-HRQL gas/bloat component; scores were significantly lower after MSA than after NF (1.3 vs. 2.4, $P = 0.059$); in this study, the preoperative scores were not provided, and the median follow-up was different between groups: 6 months for MSA and 10 months for NF. Warren et al.[32] also investigated the prevalence of postoperative AB after MSA versus NF in a retrospective cohort study, including 415 patients across three high-volume centers. At 1 year, postoperative AB was reported significantly more often after NF than after MSA (59% vs. 47%, $P = 0.03$). Furthermore, 40% (74/185) of patients in the NF group reported mild AB, whereas 27% (45/169) in the MSA group reported mild AB. Similarly, O'Neill et al.[37] used the GERD-HRQL gas/bloat score to compare the pre- and postoperative AB severity between MSA ($n = 25$) and NF ($n = 40$); postoperative AB severity decreased in both groups, but it was more prominent in the MSA group: the MSA group reported a median overall reduction of 50% (3.0 to 1.5 points), whereas the NF group reported a reduction of 25% (4.0 to 3.0 points).

Wong et al.[38] were the first to compare the prevalence of postoperative AB in patients who underwent ARMS ($n = 33$) or NF ($n = 67$) in a retrospective review. AB was measured using the GERD-HRQL gas/bloat tool preoperatively and postoperatively at 3 weeks, 6 months, 1 year, and 2 years. The mean preoperative gas/bloat score was higher for the NF group, although the difference was not statistically significant ($NF = 2.6 \pm 1.7$ vs. $ARMS = 1.8 \pm 1.7$, $P = 0.080$). Three weeks postoperatively, the mean gas/bloat score decreased by 26.9% in the NF group and by 44.4% in the ARMS group ($NF = 1.9 \pm 1.3$ vs. $ARMS = 1.0 \pm 1.2$, $P = 0.020$). At six months postoperatively, AB remained relatively constant ($NF = 1.8 \pm 1.3$ vs. $ARMS = 1.0 \pm 1.5$, $P = 0.040$). There was a dramatic reduction in AB in the ARMS group 1 year postoperatively ($NF = 1.7 \pm 1.4$ vs. $ARMS = 0.2 \pm 0.4$, $P = 0.001$). Most patients in both the NF and ARMS groups (89.6% vs. 90.9%, $P = 0.81$) were able to discontinue the use of proton pump inhibitors postoperatively; however, 30.3% ($n = 10$) of patients presented with symptomatic recurrence of reflux or pathological pH monitoring after ARMS, requiring laparoscopic redo-ARS. Two years postoperatively, both groups saw an increase in their gas/bloat scores, but the improved mean scores in the ARMS group ($n = 6$) persisted, whereas those in the NF group ($n = 22$, including those converted to a NF after ARMS) did not ($ARMS = 0.5 \pm 0.8$, $P = 0.031$ vs. $NF = 2.1 \pm 1.7$).[38]

More recently, Callahan et al.[39] conducted a large retrospective cohort study including 649 patients who underwent NF, TF, MSA, or ARMS as primary surgical management of GERD; the pre- and postoperative AB severity and prevalence among the different surgical approaches were assessed using the GERD-HRQL gas/bloat tool; at the 5-year follow-up, a decrease in the mean AB severity score was reported for all of the surgical approaches: 31.8% (2.2 to 1.5 points) for NF, 15.0% (2.0 to 1.7 points) for TF, 38.1% (2.1 to 1.3 points) for MSA, and 47.4% (1.9 to 1.0 points) for ARMS; however, these differences were not statistically significant. A comprehensive summary of the reviewed literature is presented in Table 1.

DISCUSSION

Currently, there is no reliable objective measurement for AB. This is likely due to the significant role

Table 1 Studies included in the review reporting the prevalence of AB or QoL scores after ARS

Author (year)	Country	Study type and total number of subjects	Age, years	Type of ARS	F/U, months	AB prevalence before ARS, no.	AB prevalence after ARS, no.	Tool used for evaluation	Last QoL f/u reported, months	Gas/Bloat score before ARS	Gas/Bloat score after ARS	
Papasavas et al. (2002)[34]	USA	Prospective cohort	339	46 [18–82]*	Nissen = 278 Toupet = 61	26 [1–59]*	Unk	Unk	10-point severity scale	24	Patients with score < 3 = 129 (38.1%)	Patients with score > 3 = 210 (61.9%)
Broeders et al. (2010)[24]	Australia	Meta-Analysis	231 227	[43–59]* [45–58]*	Nissen LAF (180°)	12	Unk	36 (18.0%) 21 (11.0%)	Not included			
Shan et al. (2010)[27]	China	Meta-analysis	690 529	[45–59]* [44–62]*	Nissen Toupet	[3-60]*	Unk	327 (47.4%) 128 (26.1%)	Not included			
Toydemir et al. (2011)[28]	Turkey	Prospective Cohort	684 316	39 ± 11† 41 ± 11†	Nissen Toupet	51 ± 16† 44 ± 17†	Unk	168 (19.6%) 134 (10.8%)	Not included			
Watson et al. (2012)[29]	Australia	RCT	39 40	46 (42–49)‡ 46 (42–49)‡	Nissen LAF (90°)	60	Unk	27 (80.0%) 12 (32.4%)	10-point severity scale	60	Unk	
Koch et al. (2013)[35]	Austria	RCT	62 63	50 [20–76]* 52 [25–81]*	Nissen Toupet	12 12	Unk	Unk	GIQLI	12	11.6 ± 8.17† 9.32 ± 6.87†	6.43 ± 6.31† 5.43 ± 5.96†
Louie et al. (2014)[36]	USA	Retrospective Cohort	32 34	47 ± 12† 54 ± 12†	Nissen MSA	10 6	Unk	Unk	GERD-HRQL	10 6	Unk	2.4 1.3
Riegler et al. (2015)[31]	Austria	Prospective Cohort	202 47	47 ± 14† 53 ± 13†	MSA Nissen/Toupet	12	Unk	20 (10.0%) 15 (31.9%)	GERD-HRQL	12	Unk	
Ganz et al. (2016)[25]	USA	Prospective Cohort	100	53 [18–75]*	MSA	60	52 (52%)	7 (8.3%)	GERD-HRQL	60	2.9 ± Unk†	0.3 ± Unk†
Warren et al. (2016)[32]	USA	Retrospective Cohort	214 201	52 (43–64)‡ 54 (42–64)‡	Nissen MSA	12	Unk	109 (59.0%) 79 (47.0%)	GERD-HRQL	12	Unk	Mild: 74 (40%) Moderate: 30 (16%) Severe: 6 (3%) Mild: 45 (27%) Moderate: 24 (14%) Severe: 8 (5%)
Skubleny et al. (2017)[33]	Canada	Meta-Analysis	273 415	52 [44–53]* 50 [47–54]*	Nissen MSA	[7–16]* [7–12]*	Unk	124 (53.4%) 99 (26.7%)	GERD-HRQL	Unk		
Wong et al. (2020)[38]	USA	Retrospective Cohort	67 33	57 ± 12† 55 ± 17†	Nissen ARMS	6 (3–15)‡ 18 (3–49)‡	Unk	Unk	GERD-HRQL	24	2.6 ± 1.7† 1.8 ± 1.7†	2.1 ± 1.7† 0.5 ± 0.8†
O'Neill et al. (2021)[37]	USA	Retrospective Cohort	45 25	49 ± 14† 52 ± 14†	Nissen MSA	65 (62–69)‡ 68 (65–74)‡	Unk	Unk	GERD-HRQL	60	4 [3–5]* 3 [3–4]*	2.0 [1.0–4.0]* 2.0 [0.5–4.0]*
Kim et al. (2021)[26]	Korea	Retrospective Cohort	310	49 ± 18†	Nissen = 37 Dor = 13 Toupet = 6	12	Unk	13 (23.2%)	5-point severity scale	12	Unk	
Callahan et al. (2022)[39]	USA	Retrospective Cohort	356 207 46 40	65 ± 12† 67 ± 14† 56 ± 14† 56 ± 18†	Nissen Toupet MSA ARMS	20 (3–48)‡ 11 (3–22)‡ 22 (5–39)‡ 5 (1–25)‡	Unk	Unk	GERD-HRQL	60	2.2 ± 1.7† 2.0 ± 1.4† 2.1 ± 1.4† 1.9 ± 1.6†	1.5 ± 1.4† 1.7 ± 1.3† 1.3 ± 1.6† 1.0 ± 0.0†

All the data presented is rounded to the nearest decimal or unit. Abbreviations: f/u, follow-up; LAF, laparoscopic anterior fundoplication; Unk, unknown data.
*Median, range. †Mean, standard deviation. ‡Median, interquartile range.

of visceral hypersensitivity in the patient-reported sensation of AB.[5] Physical measurements, primarily abdominal distension, have been proposed as an objective measurement of AB, but abdominal distension is noted in as few as 48% of patients reporting AB.[19] The measurement of outcomes in terms of AB is also limited because there is no standardization of the routine application of tools, such as clinical questionnaires, that can quantify the severity of the symptom and its impact on the patient's QoL. In most of the studies presented, the severity of AB and its prevalence is reported; however, the patient's general satisfaction concerning AB before and after ARS is not specifically addressed.

Several symptom severity and QoL questionnaires have been developed to assess AB. Two have been developed by the Rome Foundation: the Irritable Bowel Syndrome Severity Scoring System (IBS-SSS) and the Irritable Bowel Syndrome Quality of Life questionnaire (IBS-QOL). The IBS-SSS measures AB severity across four categories: pain, distension, bowel score, and QoL, whereas the IBS-QOL measures the social impact of patients' bowel problems.[40,41] Clinically, the Rome IV diagnostic criteria for IBS can be used in tandem with the respective criteria for functional AB/distention for optimal diagnosis, evaluation, and treatment of AB.[42,43]

Several other IBS QoL questionnaires assessing the social impact of bloating have been published. These include the Functional Digestive Disorders Quality of Life Questionnaire, which assesses functional digestive disorders and their physical, psychological, and perceptual impact[44]; the Intestinal Gas Questionnaire, which includes halitosis, stomach rumbling, and difficult gas evacuation and measures their effect on QoL[45]; and lastly, the EQ-5D, a generic test developed by EuroQol to assess the gastrointestinal well-being and the patient's QoL as the basis for clinical decision-making.[46] However, these questionnaires are not routinely used in clinical practice for patients with GERD.

The prevalence of pre- and postoperative AB in GERD patients and the related impacts on QoL remain unclear. Historically, AB has been primarily measured after ARS; however, without the availability of preoperative scores, there is little to glean regarding the effect of ARS surgery per se. Additionally, AB in those considering surgical intervention is likely to be more common and more severe.[25]

The severity of AB appears to be reduced by ARS in most surgical approaches. All of the trials analyzed in this narrative review found decreased postoperative AB. Although the magnitude of postoperative AB reduction varied between studies, TF, MSA, ARMS, DF, and anterior 90° fundoplication consistently resulted in lower rates of postoperative AB than NF. Interestingly, in the study conducted by Callahan et al.,[39] the differences in the postoperative AB between surgical approaches were not statistically significant.

This review is limited by its central focus on AB. Furthermore, epigastric pain is a common, but poorly specific, symptom among patients with GERD which can be mistaken for bloating.[23] The presentation of epigastric pain differs according to the underlying cause, which is multifactorial in most cases. It can be isolated or can overlap with a cluster of symptoms, including heartburn, AB, and early satiety.[47] This complexity can hinder a clear differentiation between epigastric pain and AB. In addition to epigastric pain, other symptoms, such as flatulence or diarrhea, can coexist with AB, especially in patients with IBS.

CONCLUSIONS

Bloating is a common though non-specific gastrointestinal symptom reported as part of the symptomatology of a wide array of gastrointestinal disorders ranging from mechanical bowel obstruction to functional disorders such as IBS or dyspepsia. GERD and bloating are commonly reported together and hypothetically linked through a positive feedback loop in which aerophagia and bloating lead to more frequent TLESRs, leading to increased swallowing (and aerophagia) in an effort to curb reflux symptoms. However, at present, the gastrointestinal causes of AB such as IBS, dyspepsia, or functional heartburn cannot be distinguished.

The preoperative prevalence of AB in patients with GERD remains unclear; however, it can be as high as 50%. Overall, patients report less severe and less frequent AB after ARS. Higher rates of postoperative AB after NF were found compared to the other surgical approaches; however, NF also improved patients' gastrointestinal well-being as measured via the GIQLI questionnaire. Although in most of the studies, lower rates of postoperative AB were reported by patients who underwent MSA than by those who underwent NF or TF fundoplication, the improvement in postoperative QoL was similar. However, the proportion of patients reporting AB after MSA (a procedure that purportedly preserves the ability to belch) is still quite high, clearly indicating that the reported AB after ARS is not due solely to the inability to belch after traditional procedures (NF or TF).

The gap in knowledge related to AB in patient's with GERD is clear. Standardization in assessing the severity and prevalence of AB in clinical practice is essential, and the traditional belief of blaming postoperative bloating as a sequela of ARS should be reevaluated. Furthermore, additional research to establish

strategies to predict the postoperative persistence of AB and its impact on QoL and patient satisfaction is paramount to improving patient selection for ARS.

KEY LEARNING POINTS

- AB is reported by up to 50% of patients with GERD. Furthermore, bloating is often cited as an undesirable sequela of ARS, with a reported incidence ranging from 10% to 80%.
- To date, there is no objective method to measure and monitor AB in patients with GERD; the evaluation of its severity is limited to QoL questionnaires.
- Patients who underwent NF reported a higher prevalence of AB than those who underwent partial fundoplication, MSA, or ARMS.

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