Obesity Surgery (2020) 30:1102–1111
https://doi.org/10.1007/s11695-019-04253-0

REVIEW

Diagnostic and Therapeutic Management of Post-Gastric Bypass Chronic Diarrhea: a Systematic Review

Camille Sollier[1] · Charles Barsamian[1] · Marion Bretault[2] · Tigran Poghosyan[3,6] · Gabriel Rahmi[4,6] · Jean-Marc Chevallier[3,6] · Jean-Luc Bouillot[5,7] · Claire Carette[1] · Sébastien Czernichow[1,6] · Claire Rives-Lange[1,6]

Published online: 4 January 2020

Abstract

There is a lack of recommendation regarding exploration and treatment of chronic diarrhea following gastric bypass, while it is a common side effect of this surgery. The electronic databases MEDLINE and EMBASE were searched until July 2018. Of the 553 articles identified, 35 articles were included. Intestinal bacterial overgrowth and pancreatic exocrine insufficiency are the main etiologies of diarrhea following gastric bypass. The diagnostic approach must begin by eliminating infectious causes of diarrhea. Exocrine pancreatic insufficiency can be diagnosed with fecal fat quantification or fecal elastase 1 level evaluation. A positive lactulose breath test confirms suspicion of small intestine bacterial overgrowth. In conclusion, we propose sequential exploration and treatment of the possible etiologies of diarrhea depending on clinical symptoms.

Keywords Diarrhea · Gastric bypass · Bariatric surgery

Abbreviations

AGB	Adjustable gastric banding
BPD	Bilio-pancreatic diversion
DANGT	Diabetic autonomic neuropathy of the gastrointestinal tract
dRYGB	Distal Roux-en-Y gastric bypass
DS	Duodenal switch
IBD	Inflammatory bowel disease
SIBO	Small intestine bacterial overgrowth
LBT	Lactulose breath test

Camille Sollier and Charles Barsamian contributed equally to this work.

✉ Claire Rives-Lange
claire.rives-lange@aphp.fr

Camille Sollier
camillesollier@hotmail.fr

Charles Barsamian
charles.barsamian@aphp.fr

Marion Bretault
marion.bretault@aphp.fr

Tigran Poghosyan
tigran.poghosyan@aphp.fr

Gabriel Rahmi
gabriel.rahmi@aphp.fr

Jean-Marc Chevallier
jean-marc.chevallier@aphp.fr

Jean-Luc Bouillot
bouillot.jeanluc@neuf.fr

Claire Carette
claire.carette@aphp.fr

Sébastien Czernichow
sebastien.czernichow@aphp.fr

[1] AP-HP, Department of Nutrition, Centre spécialisé de l'Obesité Hôpital Européen Georges Pompidou, Paris, France

[2] AP-HP, Department of Nutrition, Hôpital Ambroise Paré, Boulogne-Billancourt, France

[3] AP-HP, Department of Digestive Surgery, Hôpital Européen Georges Pompidou, Paris, France

[4] AP-HP, Department of Gastroenterology, Hôpital Européen Georges Pompidou, Paris, France

[5] AP-HP, Departement of Digestive Surgery, Hopital Ambroise Paré, Boulogne-Billancourt, France

[6] University of Paris, Paris, France

[7] University of Versailles Saint Quentin en Yvelines, Saint Quentin en Yvelines, France

OAGB	One anastomosis gastric bypass
PCR	Polymerase chain reaction
pRYGB	Proximal Roux-en-Y gastric bypass
RYGB	Roux-en-Y gastric bypass
SADIS	Single Anastomosis Duodeno-Ileal bypass with Sleeve gastrectomy
SG	Sleeve gastrectomy

Introduction

Bariatric surgery has increased in the last 15 years as a result of the global obesity epidemic. Bariatric surgery is the most effective therapy in severe obesity as it allows significant and long-lasting weight loss with a significant decrease of obesity-related morbidity and mortality [1]. Roux-en-Y gastric bypass (RYGB) is currently frequently performed weight-loss operation in the world [2, 3]. One anastomosis gastric bypass (OAGB) is becoming a commonly performed bariatric procedure because of its advantages compared with RYGB: similar weight loss with a shorter operative time [4]. Despite its impact on weight loss, some long-term side effects can develop after gastric bypass (RYGB or OAGB) such as chronic diarrhea. The classical definition of chronic diarrhea is at least three loose stools per day with a fecal weight of more than 200 g/day, lasting for at least 4 weeks [5]. Chronic diarrhea is typically a clinical concern when it occurs followings gastric bypass surgery. This chronic diarrhea can come from the surgery itself or from various but treatable causes by specific etiological treatments. The expected benefits of obesity surgery, including quality of life, can be negatively impacted by the occurrence of postoperative diarrhea. Most of the published studies regarding side effects of gastric bypass have focused on nutritional deficiencies risks, not on gastrointestinal symptoms. Some studies have discussed intestinal bacterial overgrowth and pancreatic exocrine dysfunction, and some have suggested different recommendations on how to treat post-bypass gastric diarrhea.

In this systematic review, we describe the frequency of post gastric bypass (RYBG and OAGB) diarrhea and its potential etiologies and treatments.

Methods

The electronic databases MEDLINE and EMBASE were searched from inception until July 2018. Search terms were as follows: (diarrhea) AND (gastric bypass OR Roux-en-Y gastric bypass OR mini gastric bypass OR omega loop gastric bypass OR one anastomosis gastric bypass). The literature search was conducted by two authors and scoring of relevance was concordant. In addition, references from selected articles of interest were scrutinized. We excluded articles not written in English, as well as those that provided no information on the prevalence of diarrhea or information regarding diagnosis or treatment.

Results

The total number of papers identified was 553 (86 duplicates) (Fig. 1). A total of 518 papers were excluded. Overall, 35 papers were included: one letter to the editor, three case reports, seven congress communications, four review articles, and 20 clinical studies.

Change in Gastrointestinal Function and Incidence of Diarrhea

Only 10 studies were designed to investigate gastrointestinal symptoms following gastric bypass surgery: five were observational prospective, three retrospective, and one randomized trial compared RYGB, OABG, bilio-pancreatic diversion (BPD), duodenal switch (DS), sleeve gastrectomy (SG), and adjustable gastric banding (AGB). Prevalence of diarrhea following RYGB ranged from 8 to 46.1% according to Potoczna et al. and El Labban et al. [6, 7]. One study reports improved diarrhea score after RYGB [8]. Diarrhea was more frequent after DS or BPD compared with RYGB [9–11]. Bruzzi et al. did not show any difference for diarrhea after OAGB, but the patients were compared to an unoperated control group and were not their own control [12]. This important heterogeneity of results could be explained by the use of different questionnaires according to the studies and in some small numbers of patients included. Another parameter that could explain these differences would be surgical techniques and in particular limb length. In some articles, the roux limb is 100–150 cm and biliary limb 50 cm for RYGB [6, 9–11, 13], but in three studies, we have no information on limb length [7, 8, 14] (Table 1).

Exocrine Pancreatic Insufficiency

Pancreatic exocrine insufficiency is a complication of upper gastrointestinal surgery, including bariatric surgery. This complication is multifactorial since pancreatic secretions are controlled by hormonal and neuronal pathways that could be affected by surgery. For example, release of hormones involved in pancreatic exocrine excretion (gastrin, pancreatic polypeptide, and cholecystokinin) is impaired after total gastrectomy [15].

The diagnostic gold standard is fecal fat quantification on stools collected over 3 days. FE-1 can be used to diagnose exocrine insufficiency. It requires only a small stool sample, but the sensitivity of this test cannot exclude mild to moderate insufficiency. 13C-mixed triglyceride breath test and secretin-enhanced magnetic resonance cholangiopancreatography

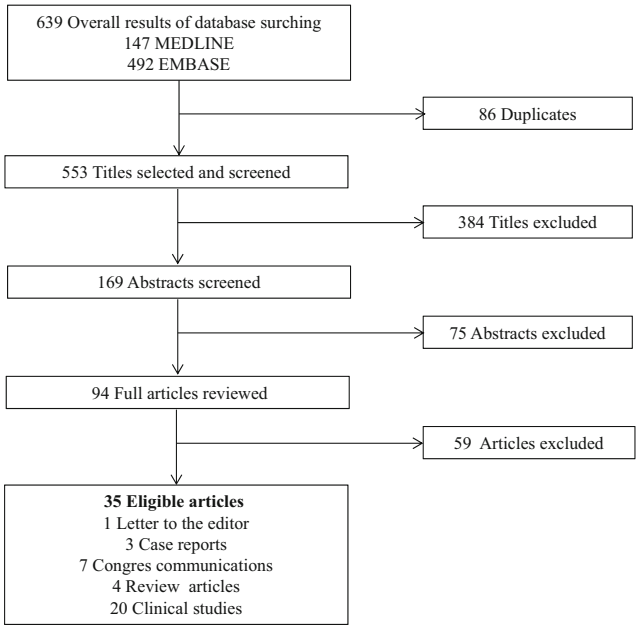


Fig. 1 Flow diagram

offer an alternative for the diagnosis of pancreatic exocrine insufficiency but are not widely available [16].

The prevalence of pancreatic exocrine insufficiency was described as 31% in a group of 188 patients who underwent distal (dRYGB) or proximal Roux-Y gastric bypass (pRYGB). There was a significant difference in the prevalence in dRYGB (48%) and pRYGB (19%; $P < 0.01$) [17]. Insufficiency was determined by measuring FE-1 and a regression of symptoms after testing pancreatic enzyme replacement therapy. A limitation is that there was no fecal analysis before surgery. Transit time and intestinal absorption after surgery were evaluated in a small group of patients by Carswell et al. [18] After AGB, RYGB, and DS, they found no impact of the surgery on transit time (evaluated by sulphasalazine/sulphapyridine tests). Fecal elastase 1 (FE-1) was significantly reduced following RYGB whereas fecal fat concentration was increased after DS [18].

In clinical setting, pancreatic enzyme therapy is sometimes used as a therapeutic test, but we did not find any evaluation of this method on symptom improvement. It seems difficult to propose long-term supplementation therapy without documented steatorrhea. Partial improvement of symptoms with pancreatic enzyme may limit the investigation of diarrhea and disregard another etiology associated with the digestive disorder.

Malabsorption Syndrome-Steatorrhea

Odstrcil et al. [19] followed up with patients before and 5 and 14 months after long-limb RYGB and showed consistent induced fat malabsorption. The importance of the malabsorption was correlated with the length of the proximal jejunum used to create the biliopancreatic limb of the Roux-Y anastomosis. In patients who had 40 or 50 cm of jejunum in their biliopancreatic limbs, malabsorption reduced fat absorption by an average of 10 g/day, whereas in patients with 70 and 75 cm diversions, fat absorption was reduced by an average of 40 g/day. The primary explanation for this is that increasing the length of the biliopancreatic limb results in a proportional shortening of the common channel. A second explanation is that increasing the jejunal portion of the biliopancreatic limb by 30 cm would delay delivery of digestive secretions to the alimentary stream, thus creating an asynchronism between the two and accentuating intraluminal destruction of pancreatic lipase. Finally, longer biliopancreatic limbs may be more apt to develop bacterial overgrowth, which would deconjugate bile acids and further retard digestion of dietary fat [20]. In a retrospective review, Soprani et al. found that severe malnutrition following OAGB was due to malabsorption syndrome with diarrhea and steatorrhea in 68% of cases [21].

Moreland et al. [22] measured oxaluria and fecal fat before and 1 year after RYGB in 26 patients. Steatorrhea was defined by a fecal fat > 7 g/day even if patients had a dietary fat intake greater than 100 g/day (mean dietary fat of 173 g/day). Prior to RYGB, 12 patients had mild to moderate steatorrhea, but only four reported diarrhea. The number of patients with steatorrhea before surgery was likely due to a high dietary fat intake. Following bariatric surgery, 24 of the 26 patients had steatorrhea (92%), and six had diarrhea, while mean fat dietary intake was lower. Fecal fat output was higher in patients who complained of diarrhea, but the correlation was not statistically significant. There was no osmotic diarrhea caused by carbohydrate malabsorption; patients had normal fecal excretion of carbohydrates after surgery [22].

Microbial bile acid deconjugation occurs in patients following total gastrectomy. Free bile acid may have a toxic effect on enterocytes. This toxicity may explain the gastrointestinal symptoms and malabsorption following gastric bypass [23].

Intestinal Bacterial Overgrowth

Small intestine bacterial overgrowth (SIBO) is defined as the accumulation of a bacterial population in the small intestine exceeding 105–106 microorganisms per milliliter. It is associated with nausea, vomiting, bloating, gas, diarrhea, and abdominal pain. It can be detected by a lactulose breath test (LBT).

In a retrospective cohort study of 313 patients, 70% of post-RYGB patients had a positive LBT tests compared to 34% in controls ($P = 0.02$). In the case of abdominal pain or diarrhea, SIBO must be considered and eliminated first, prior to other tests [24].Machado et al. [25] published a series of studies of

two women with denutrition and diarrhea after RYGB. In both patients, the respiratory hydrogen test reported bacterial hyperproliferation. Antibiotic therapy improved the symptoms at 30 days after treatment with reduction of diarrhea and increase in albuminemia, which was confirmed by clearing of the respiratory hydrogen test. In a study published by Sabate et al. [26], the prevalence of SIBO was reported to be 15% before surgery and 10% after surgery for AGB and 40% for RYGB, respectively. In the study by Moreland et al., 26 obese patients underwent a BT for SIBO. A positive test was observed for three patients before surgery and 10 patients after RYGB; however, test positivity for SIBO was not correlated with self-perception of diarrhea [22]. This lack of correlation could be due to different intestinal sensitivities, the severity of SIBO, or type of bacterial infection.

The first line of antibiotic treatment recommended in the review of the Mayo clinic is ciprofloxacin for 7 days [27]. Second-line therapy options are doxycycline, amoxicillin, metronidazole, or rifaximin.

Dumping Syndrome

Early dumping syndrome occurs within the first hour after a meal and is characterized by gastrointestinal (abdominal pain, nausea, diarrhea) and vasomotor symptoms (palpitations, flushing) [28]. Prevalence of dumping syndrome can be as high as 40% following RYGB [29]. Several phenomena are involved in dumping syndrome: the rapid delivery of undigested solid food in the small intestine, the shift of fluid from the intravascular compartment caused by hyperosmolar nutrients in the small bowel, and increased release of gastrointestinal hormones such as vasoactive intestinal peptide (VIP), gastric inhibitory polypeptide (GIP), insulin, and glucagon. Diarrhea is not described in late dumping syndrome (1–3 h after meal).

The first line of treatment involves dietary advice: avoid foods with a high glycemic index such as rapidly absorbable carbohydrates, eat slowly (20–30 min for a meal), and well-chew food. Patients should also delay fluid intake until at least 30 min after meals. Acarbose or somatostatin analog treatments may be helpful for dumping syndrome, but induced diarrhea is a known side effect of these drugs [29].

Clostridium difficile

Clostridium-associated colitis can occur following antibiotic therapy. Surgery, including bariatric procedures, is also a risk factor for *Clostridium difficile* infection. This infection must be diagnosed by PCR on liquid stool samples in the case of diarrhea after surgery and in the case of previous antibiotic treatment in the history of disease [30].

Inflammatory Bowel Disease

Crohn's disease (CD) can be suspected once all potential infectious etiologies of diarrhea are excluded [31]. Some studies presented a case report of CD after bariatric surgery. Patients had diarrhea, malabsorption, or denutrition. Diagnosis of inflammatory bowel disease (IBD) was established based on the results of colonoscopy and biopsy [23, 32, 33]. In the case report published by Janczewska et al. [32], the patient was first treated for denutrition and then for IBD and symptoms resolved in few months. For another patient, surgical reversion was decided following diagnosis of CD. In a series of cases, Mahoney presented six patients with IBD who had undergone bariatric surgery; three patients were described with chronic diarrhea [34].

IBD following bariatric surgery can be explained by the activation of innate immune factors via interaction between microbial products and host receptors or by alterations of intestinal epithelial cell metabolism by bacteria, particularly with bacterial overgrowth [23]. However, the link between IBD, immune factors, and microbial products remains controversial.

In a review of bariatric surgery in patients with IBD, Shoar et al. [35] reported results of 32 patients (25 with CD and 18 with ulcerative colitis). Patients underwent SG (62.8%), RYGB (23.2%), and GB (14%). IBD was exacerbated in 16.7% of patients; IBD status was unchanged for 28.6%; disease was in remission in 47.6%, and improvement was seen in 4.8%. No denutrition was reported after surgery.

There might be a relationship between IBD, obesity, and bariatric surgery. Onset of IBD following bariatric surgery has been described in a few case reports, suggesting that bariatric surgery may be a trigger [23, 32, 33]. On the other hand, some obese patients with IBD experienced remission or improvement following bariatric surgery [35].

Autonomic Neuropathy in Diabetic Patients and Exacerbation of Enteropathy

The prevalence of diabetic autonomic neuropathy and enteropathy is estimated to be between 8 and 40% in the diabetic population, although this may be increased with modifications caused by bariatric surgery. In a man with diabetic autonomic neuropathy of the gastrointestinal tract (DANGT), watery diarrhea occurred 2 weeks after RYGB [36]. In another patient with DANGT, upper gastrointestinal symptoms occurred 2 weeks after RYGB followed by watery diarrhea. A respiratory hydrogen test suggested bacterial overgrowth, but after several antibiotic schemes, diarrhea persisted. Both patients were well controlled with HbA1c < 6% without antidiabetic therapy and taking a full dose of loperamide improved symptoms [36]. Autonomic neuropathy alters grelic and colonic motricity, promoting endoluminal bacterial overgrowth

Table 1 Changes in gastrointestinal function in the listed studies (references [6–14, 41])

Study (author, year, type)	Patients (number, surgery type)	Purpose and assessment method	Conclusion
Foster et al. 2003, prospective	43 RYGB	Evaluated changes in gastrointestinal symptoms before and 6 months after RYGB using a gastrointestinal symptom questionnaire with a Liekert scale from 0 to 100.	Increased passage of stools after RYGB, 6.5 ± 11.7 vs. 23.9 ± 26.7 ($P = 0.0005$) and increased urgent defecation, 14.3 ± 19.3 vs. 34.3 ± 26.5 ($P = 0.0009$).
Wassenberg et al. 2008, prospective	18 RYGB, 28 DS	Compared bowel habits between BPD and RYGB after losing 50% of excess body weight using a specific questionnaire over 14 days.	More bowel episodes after duodenal switch over a week (23.5) compared with after RYGB (16.5; P = NS). No difference in other bowel parameters.
Potoczna et al. 2008, prospective	126 RYGB, 61 AGB, 103 BPD	Investigated changes in bowel habits before and 3 months after surgery with a questionnaire designed for the study.	Patients after RYGB reported a sevenfold increase in the frequency of loose stools or diarrhea (46.1% vs. 7.9% before vs. after surgery, P = NS).
Søvik et al. 2012, randomized	31 RYGB, 29 DS	Compared changes in gastrointestinal side effects and quality of life before and at 1 and 2 years after surgery using gastrointestinal symptom rating scale, bowel function, and obesity-related problems scale.	Duodenal switch group reported more symptoms of diarrhea than RYGB ($P = 0.0002$).
Peteriet al. 2014, prospective	180 RYGB	Investigated gastrointestinal symptoms and changes in eating behavior before and 1 year after RYGB. Three questionnaires were used: gastroesophageal reflux, gastrointestinal symptom rating scale, and an eating questionnaire.	Scores of gastroesophageal reflux and gastrointestinal symptoms were significantly decreased after surgery.
Bruzzi et al. 2014,	126 OAGB, 63 control	Determined quality of life and gastrointestinal symptoms after OAGB with the gastrointestinal quality of life index (GIQLI).	No difference in diarrhea between operated patients and a control group of non-operated patients: 2.8 ± 1.3 vs. 2.9 ± 1.3 (P = NS).
retrospective El Labban et al. 2015, retrospective	30 RYGB, 30 SG	Compared dietary intake, food preferences, and gastrointestinal symptoms at 6 months postoperatively with three specific questionnaires.	After RYGB, diarrhea was significantly more frequent (8%) compared to SG (4%, $P < 0.05$) and flatulence (26% vs. 15%, $P < 0.001$).
Sima et al. 2015, retrospective	489 RYGB	Series of gastrointestinal symptoms were investigated on a 3-graded Liekert scale in patients 5 years after RYGB was performed with three different gastro-jejunal anastomosis techniques.	No difference was found between the linear stapler, 21-mm circular stapler, and 25-mm circular stapler techniques for diarrhea present in 3.6, 9.4, and 13.3% of patients, respectively.
Skogar et al. 2017, retrospective	98 RYGB, 113 BPD	Compared symptoms after RYGB and BPD and with bariatric analysis and reporting outcome system and gastrointestinal symptoms.	Diarrhea was the most prominent gastrointestinal symptom following surgery: 59% with BPD vs. 20% with RYGB ($P < 0.05$).
Nickel et al. 2017, prospective	73 RYGB, 36 SG	Determined differences in gastrointestinal quality of life before and after RYGB or SG with GIQLI score.	No difference in total GIQLI score between SG and RYGB at 24 months after surgery.

RYGB, Roux-en-Y gastric bypass; *OAGB*, one anastomosis gastric bypass; *BPD*, bilio-pancreatic diversion; *SG*, sleeve gastrectomy; *AGB*, adjustable gastric banding; *DS*, duodenal switch

aggravating diarrhea. Moreover, a loss of the mechanisms of colonic inhibitory control is observed.

Celiac Disease

As for any patients with chronic diarrhea, celiac disease can be responsible for digestive symptoms even in obese patients without denutrition. Surgery can be a trigger for the development of digestive symptoms. Specific blood antibody assays and duodenal biopsy must be performed. Treatment is a gluten-free diet [37].

De Novo Food Intolerances and Gluten Sensitivity

In Europe, approximately 5–15% of the Caucasian population is lactose intolerant because of a primary or secondary lactase deficiency. There are no precise data regarding this following bariatric surgery, but some studies have indicated that approximately 5–10% of patients will develop de novo lactose intolerance following gastric bypass or biliopancreatic derivation. This can be explained by a faster passage of lactose from the gastric pouch to the small bowel, without adaptation of lactase activity. The recommendation in the case of lactose intolerance is a lactose-controlled diet [38].

Postoperative symptoms can resemble gluten sensitivity symptoms, which are widely under-diagnosed. Rutledge et al. studied the prevalence of gastrointestinal symptoms in the pre- and postoperative period of OAGB in 1595 patients, and the impact of a gluten-free diet on these symptoms. Overall, 50.6% of patients reported gluten sensitivity after surgery and half of them "had gotten better" after following a gluten-free diet. This rate is likely to be higher in bypass patients than in the general population [39]. Apart from gluten sensitivity, a celiac disease must sought because it can cause diarrhea without undernutrition [37].

Exacerbation of Irritable Bowel Syndrome

Paradoxically, in a prospective study, irritable bowel-type symptoms (such as abdominal distension, increased flatus, urgent need for defecation, and decreased and increased passage of stools) were significantly improved 6 months after RYBG. This can be explained by the decreased intra-abdominal pressure due to obesity [12]. By contrast, Lee reported in a review that diarrhea can be secondary to irritable bowel syndrome exacerbated by surgery [40].

Common Channel

Many studies suggest that a shorter common channel in gastric bypass leads to a higher frequency of diarrhea [42]. In a Norwegian study, 113 obese patients were randomized between a standard gastric bypass (alimentary limb, 150 cm) and distal gastric bypass (common limb, 150 cm). Seven patients reported diarrhea in the distal gastric bypass group, among which two patients developed severe diarrhea and malnutrition, and required reoperation with prolongation of the common channel. There was no reported diarrhea in the standard gastric bypass group [43]. After shortening the common channel in 11 patients who experienced weight regain after RYGB, seven patients developed diarrhea requiring a second procedure to lengthen the common channel leading to resolution of all symptoms [44].

The importance of common channel length is also evidenced by more diarrhea prevalence after BPD compared to RYGB. Diarrhea was significantly more frequent after BPD (77.7% of patients) than RYGB (46.1%) in 290 obese patients; the length of the alimentary limb was estimated to be 80–100 cm in RYGB and approximately 250 cm in BPD [6]. In a smaller patient population, Wassenberg et al. also showed more bowel episodes after BPD compared to RYGB [11].

Severe Diarrhea and Revisional Surgery

Severe diarrhea is one of the causes of revision of bariatric surgery. For RYGB, diarrhea was the main indication for reversal in three cases. Symptoms were resolved for these patients following reestablishment of normal anatomy [45]. In the case of severe diarrhea and malnutrition in patients with distal RYGB, conversion to proximal RYGB allows resolution of symptoms [44]. Poghosyan et al. reported 17 patients who underwent OAGB conversion to RYGB. Eleven patients had diarrhea with OAGB, and conversion to RYGB resolved the symptoms for 64% of patients. Eight patients who had steatorrhea were healed after conversion of OAGB to RYGB [46]. Conversion of OAGB to RYGB seems to improve diarrhea and steatorrhea.

In another type of surgery like a single anastomosis duodeno-ileal switch (SADIS), diarrhea was the most common complication. Diarrhea was resolved after lengthening the common channel [47].

Niacin Deficiency

Niacin deficiency is responsible for pellagra, a disease characterized by diarrhea, dermatitis, and dementia [48]. Three cases of pellagra have been described following bariatric surgery. Two patients had a cutaneous rash, diarrhea, and neurological signs [49, 50]. In one other case, the patient did not have diarrhea, which complicates the classical diagnosis [51]. Treatment is based on oral niacin with an excellent prognosis of recovery [48].

Fecal Incontinence

Functional fecal incontinence is frequent in obese patient and the risk of incontinence increases with BMI. Diarrhea is a risk factor for fecal incontinence. If worsening or occurrence of fecal incontinence occurs, diarrhea should be sought and treated [52].

Discussion

Considerations and Recommendations for Post-Gastric Bypass Chronic Diarrhea

Patients often present with diarrhea after bariatric surgery and several potential causes may be involved. We have included a diagram for diagnostic support based on the studies. The causes of diarrhea after bypass are numerous and may overlap.

Subsequent publications provide additional information on this topic. Robert et al. compared outcomes between RYGB and OAGB in the prospective, randomized, multicenter YOMEGA study on 234 patients. The incidence of diarrhea was significantly higher after OAGB (26%) at 3 months versus after RYGB (3.2% $P = 0.003$). Steatorrhea was also significantly higher after OAGB [53]. These differences for diarrhea, steatorrhea, and more nutritional complications suggest greater malabsorption after OAGB compared to RYGB. A retrospective study on 925 OAGB focused on causes and management of revision. Five patients (0.5%) had severe diarrhea; they were managed by shortening of the bilio-pancreatic limb from 200 to 150 cm. The authors suggest that a 150-cm bilio-pancreatic limb might lower the complication rate after OAGB [54]. These recent data are to be taken into account if revision surgery is considered. (Major comment, reviewer 2).

We propose sequential exploration and treatment of the main possible etiologies of diarrhea depending on clinical history and symptoms (Fig. 2).

Before any exploration, an infectious cause must be eliminated. *C. difficile* infection should always be suspected following antibiotic treatment; this infection can occur following digestive surgery [30]. A stool culture is also indicated to eliminate an infectious cause of diarrhea [31].

Medication may be the cause of digestive disorders, when possible, stopping or changing the imputable drug must be tried. Food inquiry must include the intake of sweeteners, because of their laxative effect in high quantities. Diarrhea can stem from lactose intolerance due to lactase enzyme deficiency. Diagnosis can be made based on the improvement of digestive symptoms after following a lactose-free diet [38].

Specific blood antibody assays must be performed to eliminate celiac disease, if positive, the diagnosis must be confirmed on duodenal biopsy [37].

If all these explorations are negative, we propose targeted exploration according to symptoms associated with diarrhea.

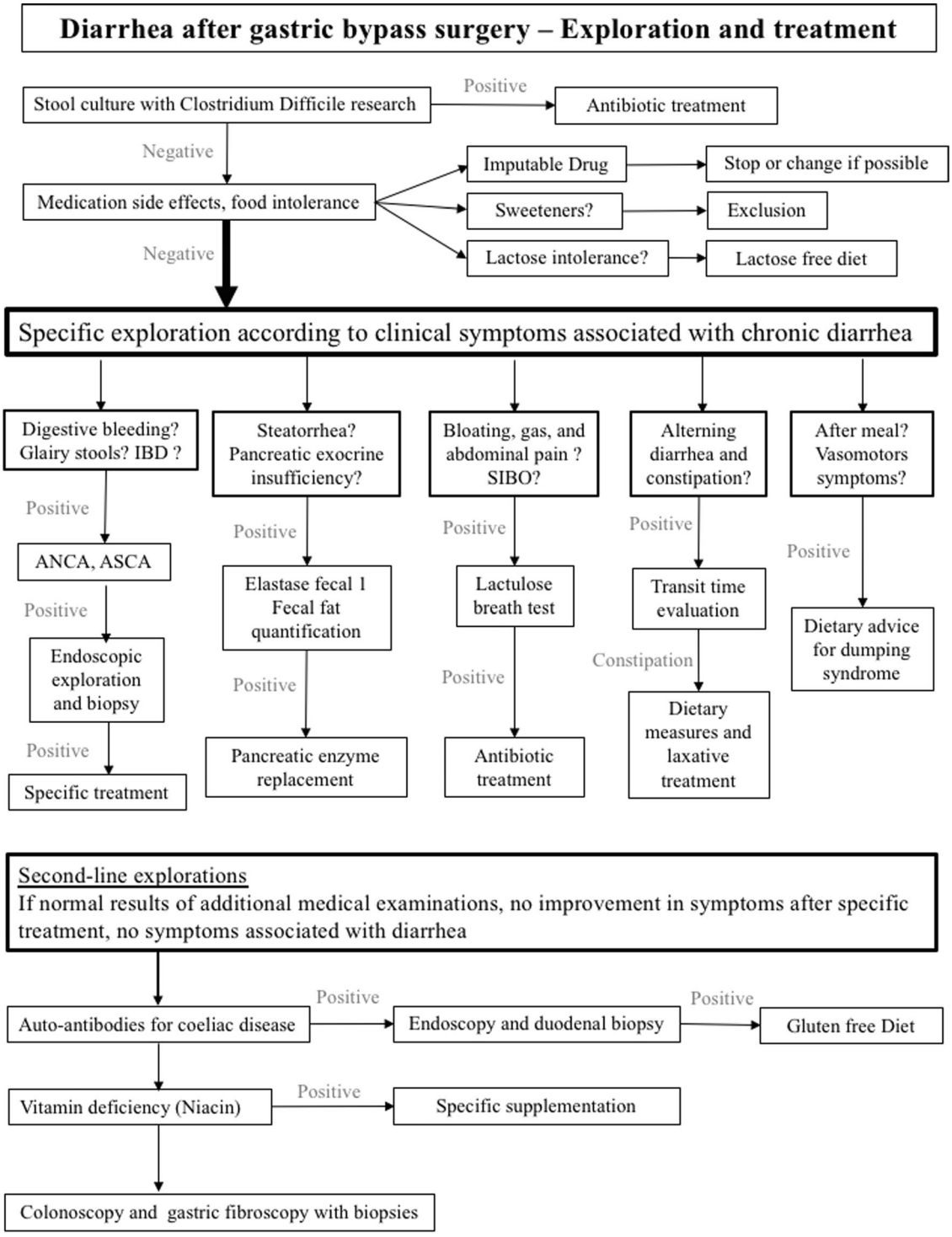
In the presence of digestive bleeding or glairy stools, specific antibodies and endoscopic exploration should be performed, as in non-obese patients or with no previous surgical history [31].

Diarrhea is more frequent in malabsorptive surgery, and the incidence appears to be proportional to the alimentary light limb, suggesting that diarrhea can be related to partial exocrine pancreatic insufficiency and malabsorption following RYGB, OLGB, and BPD. In a recent study, Robert et al. showed a greater incidence of the diarrhea after OLGB than RYGB [53]. (Major comment, reviewer 2). Steatorrhea and FE-1 tests should be performed first. These tests may not be able to exclude mild to moderate exocrine pancreatic insufficiency; other explorations should be performed if this diagnosis is suspected. A test with pancreatic enzyme replacement therapy can be used [21, 22].

SIBO is common following bariatric surgery. Foster et al. suggested administering a breath test before any exploration of diarrhea or abdominal pain [24]. A subsequent study showed that some patients with a positive test for SIBO did not experience diarrhea [22]. The link between diarrhea and SIBO remains unclear. An LBT should be a part of the exploration of diarrhea. If the test is positive, antibiotic treatment is recommended: ciprofloxacin in first intention [27]. In case LBT is not accessible, empiric antibiotic treatment may be administered [27].

In the case of alternating diarrhea with diarrhea, a "false" diarrhea with chronic constipation must be suspected. The use of antidiarrheal medication can aggravate their symptoms. Measuring transit time using ingested radiographic markers may be useful. We found no publications on this subject in our review, but we were frequently confronted with our patients. Diarrhea that occurs 1 h after a meal is characteristic of dumping syndrome. Dietary measures can reduce this diarrhea [29]. In second line explorations, vitamin deficiency (niacin) must be searched and treated [49, 50]. If all explorations are negative, diarrhea must be explored by endoscopy. We found contradictory data regarding the effects of bariatric surgery on irritable bowel syndrome [14, 40]. This syndrome is a diagnosis of elimination and can only be retained after an exhaustive exploration of diarrhea.

Diarrhea after gastric bypass is a frequent complication, which in addition to the medical consequences can also alter considerably alter the quality of life, impacting the expected benefits of the surgery. It seems important to inform them of this potential complication and to discuss with them possible explorations and care.



ANCA:Anti-neutrophil cytoplasmic antobody ; ASCA: Anti-saccharomyces cerevisae antibody ;
IBD: Inflammatory bowel diseases; SIBO: Small intestinal bacterial overgrowth

Fig. 2 Diagram of exploration for diarrhea following gastric bypass

Compliance with Ethical Standards

Conflict of Interest The authors declare that they have no conflicts of interest.

References

1. Sjöström L. Review of the key results from the Swedish obese subjects (SOS) trial – a prospective controlled intervention study of bariatric surgery. J Intern Med. 2013;273:219–34. https://doi.org/10.1111/joim.12012.
2. Su YH, Lee WJ, Lee Y-C, et al. P-37 Gastrointestinal symptoms after bariatric surgery: a comparison of Roux-en-Y and mini gastric bypass. Surg Obes Relat Dis. 2011;7:384–5. https://doi.org/10.1016/j.soard.2011.04.038.
3. Edholm D, Svensson F, Näslund I, et al. Long-term results 11 years after primary gastric bypass in 384 patients. Surg Obes Relat Dis. 2013;9:708–13. https://doi.org/10.1016/j.soard.2012.02.011.
4. Mahawar KK, Jennings N, Brown J, et al. "Mini" gastric bypass: systematic review of a controversial procedure. Obes Surg. 2013;23:1890–8. https://doi.org/10.1007/s11695-013-1026-8.
5. Cooper BT. Diarrhoea as a symptom. Clin Gastroenterol. 1985;14:599–613.
6. Potoczna N, Harfmann S, Steffen R, et al. Bowel habits after bariatric surgery. Obes Surg. 2008;18:1287–96. https://doi.org/10.1007/s11695-008-9456-4.
7. El Labban S, Safadi B, Olabi A. The effect of Roux-en-Y gastric bypass and sleeve gastrectomy surgery on dietary intake, food preferences, and gastrointestinal symptoms in post-surgical morbidly obese Lebanese subjects: a cross-sectional pilot study. Obes Surg. 2015;25:2393–9. https://doi.org/10.1007/s11695-015-1713-8.
8. Nickel F, Schmidt L, Bruckner T, et al. Gastrointestinal quality of life improves significantly after sleeve gastrectomy and Roux-en-Y gastric bypass-a prospective cross-sectional study within a 2-year follow-up. Obes Surg. 2017;27:1292–7. https://doi.org/10.1007/s11695-016-2464-x.
9. Søvik TT, Karlsson J, Aasheim ET, et al. Gastrointestinal function and eating behavior after gastric bypass and duodenal switch. Surg Obes Relat Dis. 2013;9:641–7. https://doi.org/10.1016/j.soard.2012.06.006.
10. Skogar ML, Sundbom M. Duodenal switch is superior to gastric bypass in patients with super obesity when evaluated with the bariatric analysis and reporting outcome system (BAROS). Obes Surg. 2017;27:2308–16. https://doi.org/10.1007/s11695-017-2680-z.
11. Wasserberg N, Hamoui N, Petrone P, et al. Bowel habits after gastric bypass versus the duodenal switch operation. Obes Surg. 2008;18:1563–6. https://doi.org/10.1007/s11695-008-9658-9.
12. Bruzzi M, Rau C, Voron T, et al. Single anastomosis or mini-gastric bypass: long-term results and quality of life after a 5-year follow-up. Surg Obes Relat Dis. 2015;11:321–6. https://doi.org/10.1016/j.soard.2014.09.004.
13. Petereit R, Jonaitis L, Kupčinskas L, et al. Gastrointestinal symptoms and eating behavior among morbidly obese patients undergoing Roux-en-Y gastric bypass. Medicina (Kaunas). 2014;50:118–23. https://doi.org/10.1016/j.medici.2014.06.009.
14. Foster A, Laws HL, Gonzalez QH, et al. Gastrointestinal symptomatic outcome after laparoscopic Roux-en-Y gastric bypass. J Gastrointest Surg. 2003;7:750–3.
15. Friess H, Böhm J, Müller MW, et al. Maldigestion after total gastrectomy is associated with pancreatic insufficiency. Am J Gastroenterol. 1996;91:341–7.
16. Vujasinovic M, Valente R, Thorell A, et al. Pancreatic exocrine insufficiency after bariatric surgery. Nutrients. 2017;9 https://doi.org/10.3390/nu9111241.
17. Borbély Y, Plebani A, Kröll D, et al. Exocrine pancreatic insufficiency after Roux-en-Y gastric bypass. Surg Obes Relat Dis. 2016;12:790–4. https://doi.org/10.1016/j.soard.2015.10.084.
18. Carswell KA, Vincent RP, Belgaumkar AP, et al. The effect of bariatric surgery on intestinal absorption and transit time. Obes Surg. 2014;24:796–805. https://doi.org/10.1007/s11695-013-1166-x.
19. Odstrcil EA, Martinez JG, Santa Ana CA, et al. The contribution of malabsorption to the reduction in net energy absorption after long-limb Roux-en-Y gastric bypass. Am J Clin Nutr. 2010;92:704–13. https://doi.org/10.3945/ajcn.2010.29870.
20. Hashim A, Paulon E, Ahmed M. PTU-141 bile acid malabsorption: an evaluation of current practice. Gut. 2012;61:A243–3.
21. Soprani A, Carandina S, Cady J. Severe malnutrition after omega loop gastric bypass (OLGB): surgical management and results. Obes Surg. 2015:S161–1.
22. Moreland AM, Santa Ana CA, Asplin JR, et al. Steatorrhea and hyperoxaluria in severely obese patients before and after Roux-en-Y gastric bypass. Gastroenterology. 2017;152:1055–1067.e3. https://doi.org/10.1053/j.gastro.2017.01.004.
23. Ahn LB, Huang CS, Forse RA, et al. Crohn's disease after gastric bypass surgery for morbid obesity: is there an association? Inflamm Bowel Dis. 2005;11:622–4.
24. Chan WW, Thompson CC, Lautz DB, Burakoff R. Risk of small intestinal bacterial overgrowth in Roux-en-Y gastric bypass. Gastroenterology. 2011;140: S–1057.
25. Machado JDC, Campos CS, Lopes Dah Silva C, et al. Intestinal bacterial overgrowth after Roux-en-Y gastric bypass. Obes Surg. 2008;18:139–43. https://doi.org/10.1007/s11695-007-9365-y.
26. Sabate J-M, Coupaye M, Ledoux S, et al. Consequences of small intestinal bacterial overgrowth in obese patients before and after bariatric surgery. Obes Surg. 2017;27:599–605. https://doi.org/10.1007/s11695-016-2343-5.
27. Krajicek EJ, Hansel SL. Small intestinal bacterial overgrowth: a primary care review. Mayo Clin Proc. 2016;91:1828–33. https://doi.org/10.1016/j.mayocp.2016.07.025.
28. Tack J, Arts J, Caenepeel P, et al. Pathophysiology, diagnosis and management of postoperative dumping syndrome. Nat Rev Gastroenterol Hepatol. 2009;6:583–90. https://doi.org/10.1038/nrgastro.2009.148.
29. van Beek AP, Emous M, Laville M, et al. Dumping syndrome after esophageal, gastric or bariatric surgery: pathophysiology, diagnosis, and management. Obes Rev. 2017;18:68–85. https://doi.org/10.1111/obr.12467.
30. Bagdasarian N, Rao K, Malani PN. Diagnosis and treatment of clostridium difficile in adults: a systematic review. JAMA. 2015;313:398–408. https://doi.org/10.1001/jama.2014.17103.
31. DuPont HL. Persistent diarrhea: a clinical review. Jama. 2016;315:2712–23.
32. Janczewska I, Nekzada Q, Kapraali M. Crohn's disease after gastric bypass surgery. BMJ Case Rep 2011;2011. doi:https://doi.org/10.1136/bcr.07.2010.3168
33. Dodell GB, Albu JB, Attia L, et al. The bariatric surgery patient: lost to follow-up; from morbid obesity to severe malnutrition. Endocr Pract. 2012;18:e21–5. https://doi.org/10.4158/EP11200.CR.
34. Mahoney NA, El Mourabet M, Weyant K, Regueiro M, Baidoo L, Barrie A, et al. Bariatric surgery and inflammatory bowel disease. Gastroenterology. 2011;140: S–792.
35. Shoar S, Hoseini SS, Naderan M, et al. Bariatric surgery in morbidly obese patients with inflammatory bowel disease: a systematic review. Surg Obes Relat Dis. 2017;13:652–9.

36. Saba J, Rodriguez L, Reyes E, Isla O, Munoz J, Munoz S. Diabetic autonomic neuropathy of the gastrointestinal tract and bariatric surgery: a two-case report and literature review. Obes Surg; 2011. pp. 1086–1087.
37. Green PH, Jabri B. Coeliac disease. Lancet. 2003;362:383–91.
38. Raab H. Lactose intolerance-is it a problem after obesity surgery. Obes Surg. 2011:1036–6.
39. Rutledge R. The first report of gluten sensitivity as a common cause of significant gastrointestinal symptoms after mini-gastric bypass. Obes Surg. 2011:1061–1.
40. Lee CW, Kelly JJ, Wassef WY. Complications of bariatric surgery. Curr Opin Gastroenterol. 2007;23:636–43. https://doi.org/10.1097/MOG.0b013e3282f094b5.
41. Sima E, Hedberg J, Sundbom M. Gastrointestinal symptoms, weight loss and patient satisfaction 5 years after gastric bypass: a study of three techniques for the gastrojejunal anastomosis. Surg Endosc. 2016;30:1553–8. https://doi.org/10.1007/s00464-015-4374-8.
42. Borbély YM, Osterwalder A, Kröll D, et al. Diarrhea after bariatric procedures: diagnosis and therapy. World J Gastroenterol. 2017;23:4689–700. https://doi.org/10.3748/wjg.v23.i26.4689.
43. Risstad H, Svanevik M, Kristinsson JA, et al. Standard vs distal Roux-en-Y gastric bypass in patients with body mass index 50 to 60: a double-blind, randomized clinical trial. JAMA Surg. 2016;151:1146–55. https://doi.org/10.1001/jamasurg.2016.2798.
44. Ghiassi S, Higa K, Chang S, et al. Conversion of standard Roux-en-Y gastric bypass to distal bypass for weight loss failure and metabolic syndrome: 3-year follow-up and evolution of technique to reduce nutritional complications. Surg Obes Relat Dis. 2018;14:554–61. https://doi.org/10.1016/j.soard.2018.01.004.
45. Arman GA, Himpens J, Bolckmans R, et al. Medium-term outcomes after rReversal of Roux-en-Y gastric bypass. Obes Surg. 2018;28:781–90. https://doi.org/10.1007/s11695-017-2928-7.
46. Poghosyan T, Caille C, Moszkowicz D, et al. Roux-en-Y gastric bypass for the treatment of severe complications after omega-loop gastric bypass. Surg Obes Relat Dis. 2017;13:988–94. https://doi.org/10.1016/j.soard.2016.12.003.
47. Shoar S, Poliakin L, Rubenstein R, et al. Single-anastomosis duodeno-ileal switch (SADIS): a systematic review of efficacy and safety. Obes Surg. 2018;28:104–13. https://doi.org/10.1007/s11695-017-2838-8.
48. Hegyi J, Schwartz RA, Hegyi V. Pellagra: dermatitis, dementia, and diarrhea. Int J Dermatol. 2004;43:1–5.
49. Levenbergh L, Marot J-C, Wieers G. Pellagra secondary to bariatric surgery. Acta Clinica Belgica. 2017:46–6.
50. Jampala N, Kachru S, Leland W, et al. Tu2031 rare case of pellagra in a patient after Roux en-Y gastric bypass. Gastroenterology. 2016;150:S1010–1.
51. Ashourian N, Mousdicas N. Images in clinical medicine. Pellagra-like dermatitis. N Engl J Med. 2006;354:1614. https://doi.org/10.1056/NEJMicm050641.
52. Roberson EN, Gould JC, Wald A. Urinary and fecal incontinence after bariatric surgery. Dig Dis Sci. 2010;55:2606–13. https://doi.org/10.1007/s10620-010-1190-9.
53. Robert M, Espalieu P, Pelascini E, et al. Efficacy and safety of one anastomosis gastric bypass versus Roux-en-Y gastric bypass for obesity (YOMEGA): a multicentre, randomised, open-label, non-inferiority trial. Lancet. 2019;393:1299–309. https://doi.org/10.1016/S0140-6736(19)30475-1.
54. Hussain A, Van den Bossche M, Kerrigan DD, et al. Retrospective cohort study of 925 OAGB procedures. The UK MGB/OAGB collaborative group. Int J Surg. 2019;69:13–8. https://doi.org/10.1016/j.ijsu.2019.07.003.