Small bowel bacterial overgrowth following laparoscopic one-anastomosis gastric bypass: a prospective study based on small bowel aspiration and culture

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Received: 3 December 2022
Revised: 21 December 2022
Accepted: 28 December 2022
Published: 28 April 2023

The Egyptian Journal of Surgery 2023, 41:1637–1642

Background
Gastric resection for bariatric surgery is associated with nutrients deficiency, including thiamine and folic acid. Other sequelae of bypass surgeries have been described. The alteration in the anatomy and the motility pattern of the bowel may result in a blind bowel with subsequent small intestine bacterial overgrowth (SIBO).
Aim
The present study aimed to assess the prevalence of SIBO in patients undergoing one-anastomosis gastric bypass (OAGB) and the effect on thiamine and folic acid levels.
Patients and methods
The study included 40 patients planned for OAGB. Data on the prevalence of SIBO following OAGB and its implications on the nutritional status were collected.
Results
At the 6-month postoperative follow-up, the mean percentage of total weight loss was 27.61%. No statistically significant differences were found in the thiamine or folate levels as compared with the preoperative levels. A total of 20 (50%) patients had at least one GI disturbance symptom occurring at least once per week. Jejunal aspirate culture revealed SIBO in 31 (77.5%) patients. Comparing between patients according to the presence of SIBO revealed higher weight measures in patients who developed SIBO compared with those who did not. This difference reached the level of significance only in the preoperative and postoperative weight measures. There were no statistically significant differences in the percentage of total weight loss, the thiamine and folate levels, the other demographic data, or the gastrointestinal tract symptoms.
Conclusion
SIBO was highly prevalent after OAGB, with no apparent association with the thiamine or folate levels. The relationship between gastrointestinal tract symptoms and bacterial overgrowth was not statistically significant, with high incidence of asymptomatic SIBO. OAGB is an effective procedure for weight loss and resolution of comorbidities.

Keywords:
folate, obesity, one-anastomosis gastric bypass, small intestine bacterial overgrowth, thiamine

Egyptian J Surgery 41:1637–1642

1110-1121

Introduction

Obesity is a major public health problem all over the world. It is postulated that obesity is implicated in about 4.7 million deaths every year [1].

Currently, bariatric surgery has been consistently reported as the only successful management procedure for morbid obesity (BMI>40 kg/m^2) that is mostly associated with variable comorbidities. The effective value of bariatric surgery is extending to cover obesity-related comorbidities as well [2].

One-anastomosis gastric bypass (OAGB) surgery is one of the bariatric surgery procedures, which shows similarity to Roux-en-Y gastric bypass (RYGB), but with technical simplicity [3]. OAGB involves creating a narrow long pouch (similar to the sleeve gastrectomy pouch), to which the small bowel is anastomosed in an end-to-side manner about 200 cm distal to the duodenojejunal flexure (the Treitz angle). OAGB includes afferent and efferent loops rather than an alimentary limb, with bypassing the whole

 DOI: 10.4103/ejs.ejs_290_22

duodenum and the first 200 cm of the small intestine [4].

Gastric resection for bariatric surgery is associated with nutrients deficiency, including thiamine and folic acid [5]. About a third of the patients who have had bypass surgery may develop subclinical thiamine deficiency [6]. Folic acid is predominantly absorbed via the duodenum and the proximal portion of the jejunum. Its deficiency may affect the neural system and cause megaloblastic anemia [7].

Other sequelae of bypass surgeries were described. The alteration in the anatomy and the motility pattern of the bowel may result in a blind bowel with subsequent small intestine bacterial overgrowth (SIBO) [8]. SIBO is associated with abdominal symptoms including diarrhea, bloating, abdominal discomfort, and gas distention. However, it could be asymptomatic [9].

SIBO may lead to vitamin deficiency. Thiamine deficiency results from bacterial overutilization. On the contrary, bacterial synthesis leads to increase in the folate levels [10].

Many research studies have adopted using the breath test for SIBO diagnosis [11–15], with variable levels of sensitivity an specificity. Actually, the gold standard for diagnosis of SIBO is the intestinal aspirate culture [16].

Up till now, no protocol is standardized for the assessment of SIBO in patients undergoing bariatric surgeries, with no single study assessing such issue in OAGB patients using the most accurate method of diagnosis, the intestinal aspirate culture. Moreover, data assessing its prevalence and nutritional implications after OAGB are very scarce [17].

Therefore, the present study aimed to assess the prevalence of SIBO in patients undergoing OAGB and the effect on thiamine and folic acid levels.

Patients and methods

This is a prospective study that was conducted at Kasr Alainy Medical School, Cairo University, during the period from October 2020 to the end of September 2021. The study was conducted after the approval of the research ethics committee, and it was done in accordance with the Helsinki declaration.

Patients were candidates for bariatric surgery if they were adult with a BMI more than or equal to 40 or 35 kg/m^2 with comorbidities and generally fit for surgery under general anesthesia. Patients were preliminarily selected for OAGB if they had type 2 diabetes mellitus or if they were frequent sweet eaters. After offering suitable alternatives to the patients, consecutive adult patients planned for OAGB were eligible for the study if they accepted to participate in the study and to comply with the evaluation, the treatment schedule, and the postoperative follow-up.

All patients underwent preoperative evaluation including a dedicated history taking, endocrinal workup, abdominal ultrasound, psychological testing, and dietician counseling. All patients were screened for baseline thiamine and folic acid levels.

Patients with history of drugs or alcohol abuse, previous malabsorptive or restrictive procedures, and congenital or acquired diseases were excluded from the study.

Informed written consents were obtained from the included patients.

On the evening before surgery, subcutaneous low-molecular-weight heparin (40 mg) was administered for thromboembolic prophylaxis and continued daily till the patient was ambulant.

Surgical procedure

The surgery was performed under general anesthesia. While the patient in supine position, the surgeon was positioned between the patient's leg. The patients were allowed for placement in the anti-Trendelenburg position when required.

Pneumoperitoneum was induced using carbon dioxide insufflation with maintaining an intraabdominal pressure of 15 mmHg.

The five-port approach was used, and the laparoscopic operation was performed to create two components: a narrow gastric pouch, and about 200 cm from the ligament of Treitz, jejunal bypass with a single gastro-jejunostomy anastomosis in an antecolic retro-gastric direction.

First, for gastric pouch formation, a 36-Fr bougie was passed transorally, and the stomach was divided using a stapler in an upward direction parallel to the lesser curve till to the His angle while ensuring avoidance of cardia dissection.

Second, for of the jejunal bypass creation, Treitz ligament was identified by retraction of the

omentum medially. The bowel was followed to about 200 cm distal to the Treitz ligament, to which the distal end of the gastric pouch was anastomosed end-to-side to the jejunum in an antecolic direction (average stoma size 4.5 cm).

We used Ethicon and Covidien staplers and staples (using a 60 mm gold reload if Ethicon and green if Covidien for the transverse staple, 60 mm blue reloads for the vertical staples and a 60 mm blue reload if Ethicon and a 45 mm blue reload if Covidien for the gastro-jejunostomy).

Bleeding from staple line was checked and controlled by Liga clips or running sutures. Leakage was checked by methylene blue injection. Closure of the working ports was performed using an Endoclose device.

The patients' data concerning weight and height measures were assessed at the baseline and 6 months postoperatively. The amount of weight loss and the percentage of total weight loss (%TWL) were calculated at the 6-month postoperative follow-up.

The study patients were assessed for the gastrointestinal tract (GIT) symptoms based on Rome III criteria.

The serum thiamine and folic acid levels were assessed using ELISA test preoperatively and 6 months postoperatively.

Normal level of thiamine is 270–1090 pmol/l.

Normal level of folic acid is 0.8–4 nmol/l.

For detection of SIBO, patients were invited for upper GI endoscopy 6 months postoperatively in the Endoscopy Department of Kasr Alainy Medical School, Cairo University. After proper sterilization of the enteroscope and its attachments, the patients underwent enteroscopy after night fasting. Jejunal aspirate was obtained from both the afferent and the efferent loops using a 5-Fr metal-tipped ERCP cannula. One milliliter of the jejunal aspirate was placed in an anaerobic specimen collector (Becton, Dickinson and Company, New York City, USA) and subjected immediately to bacteriological analysis.

Based on the recent North American Consensus, cultures were diagnosed as positive for SIBO if the bacterial count was more than or equal to 10^3 colony-forming units per 1 ml [18].

Statistical analysis

The patients' data were recorded and analyzed using the SPSS statistical software, version 22 (IBM Corp., Armonk, New York, USA). After applying tests of normality, the independent *t* test or Mann–Whitney test was used to compare between patients according to SIBO presence, whereas paired *t* test or Wilcoxon signed-rank test was chosen to compare between numerical data at two-time settings as appropriate. χ^2 test was used to compare between qualitative data. The level of significance was considered at *P* values less than 0.05.

Results

At the baseline, this study included 47 patients, of whom seven patients did not complete the 6-month follow-up. The remaining 40 patients were predominantly females (32 females and eight males). Their ages ranged from 25 to 60 years, with a mean of 39.65 years. The patients' BMI ranged from 35.1 to 65.9 kg/m^2, with a mean 48.78 kg/m^2 (Table 1). The most common comorbidity in the study patients was diabetes mellitus (35%), followed by hypertension (27.5%), anemia (2.5%), and bronchial asthma (2.5%).

The preoperative serum levels of thiamine ranged from 60 to 143 nmol/l and the folic acid levels ranged from 32.61 to 15.2 ng/ml (Table 1).

Six-month postsurgery follow-up

At the 6-month postoperative follow-up, the %TWL ranged from 13.07 to 43.33% with a mean of 27.61%. A statistically significant reduction in weight and BMI was shown as compared with the preoperative measures (Table 1).

Table 1 Patients' data at the baseline and at 6-month postoperative follow-up

	Preoperatively Mean±SD, median (range)	6 months postoperatively Mean±SD, median (IQR)	*P*
Weight (kg)	135.96±28, 130 (90–210)	97.89±19.12, (70–134)95	$<0.001^T$
BMI (kg/m^2)	48.78±8.41, 49 (35.1–65.9)	35.19±6.2, 34.13 (26.4–48)	$<0.001^T$
Thiamine (nmol/l)	83.55±18.1, 87 (60–143)	80.98±12.38, 87 (57–97)	0.28^Z
Folic acid (ng/ml)	7.95±4.1, 7.7 (2.61–15.2)	8.3±4.63, 8.4 (2.4–20.4)	0.1^Z
%TWL	–	27.6±6.2, 27.7 (13.07–43.33)	–

%TWL, percentage of total weight loss; *t*, paired *t* test; *Z*, Wilcoxon signed-rank test.

Eight patients showed diabetes mellitus remission and 6 patients showed hypertension remission, with remission rates of 57.1 and 54.5%, respectively.

The thiamine levels ranged from 57 to 96 nmol/l, with a mean of 80.98 nmol/l. The folate levels ranged from 2.4 to 20.4 ng/ml, with a mean of 8.3 ng/ml (Table 1).

No statistically significant differences were found in the thiamine or folate levels as compared with the preoperative levels (Table 1).

A total of 20 (50%) patients had at least one GI disturbance symptom occurring at least once per week, including nausea, vomiting, regurgitation, heart burn, bloating, flatulence, diarrhea, constipation, and abdominal discomfort/pain.

Upper GI endoscopy and jejunal aspirates from the afferent and/or efferent loops revealed SIBO in 31 (77.5%) patients. Those were afferent loop SIBO in 29 (72.5%) patients and efferent loop SIBO in 25 (62.5%) patients.

Comparison between patients according to the development of small intestine bacterial overgrowth

Comparison between patients according to the presence of SIBO revealed higher weight measures in patients who developed SIBO compared with those who did not. This difference reached the level of significance only in the postoperative weight measures. No statistically significant differences in the %TWL, the thiamine and folate levels, other demographic data, or the GIT symptoms were present (Table 2).

Table 2 Comparison between patients with small intestine bacterial overgrowth and those without

	SIBO group (*N*=31) Mean±SD, median (range)	Non-SIBO group (*N*=9) Mean±SD, median (IQR)	*P*
Age (years)	41.04±9.35, 39 (29–60)	36.29±8.04, 36 (25–49)	0.66^{T}
Preoperative weight (kg)	141.2±26.8, 137.5 (100–210)	109.3±12.6, 112 (90–125)	0.058^{T}
Postoperative weight (kg)	100.8±19.3, 98.5 (70–134)	80.5±4.2, 80 (75–85)	0.04^{T}
Preoperative BMI (kg/m^2)	49.6±6.8, 50.3 (39–64.5)	39.3±3, 38.6 (35.1–43.1)	0.076^{T}
Postoperative BMI (kg/m^2)	35.5±5.8, 34.9 (27.3–48)	29±1.3, 29.3 (26.4–30.4)	0.13^{T}
Preoperative thiamine (nmol/l)	82.6±21.7, 75 (60–143)	85.7±8.11, 90 (70–92)	0.25^{U}
Postoperative thiamine (nmol/l)	78.3±12.6, 75 (57–96)	85.7±8.1, 90 (70–92)	0.21^{U}
Preoperative folic acid (ng/ml)	8.1±4.4, 7.7 (2.61–15.2)	8.5±4.4, 9.9 (3–13.6)	0.85^{U}
Postoperative folic acid (ng/ml)	8.9±5.1, 10.3 (2.4–20.4)	8±4.3, 7.5 (2.6–13.6)	0.87^{U}
%TWL	28.4±6.7, 28.7 (13.1–43.3)	25.7±6.9, 28.8 (16.7–32.1)	0.53^{T}
	n (%)	*n* (%)	
Sex			
Female	24 (77.4)	8 (88.9)	0.45^{X}
Male	7 (22.6)	1 (11.1)	
Comorbidities			
Diabetes mellitus	11 (35.5)	3 (33.3)	0.92^{X}
Hypertension	8 (25.8)	3 (33.3)	
Bronchial asthma	1 (3.2)	0	
Anemia	1 (3.2)	0	
GIT symptoms			
Yes	16 (51.6)	4 (44.4)	0.7^{X}
No	15 (48.4)	5 (55.6)	
GIT symptoms			
Nausea	3(9.7)	3 (33.3)	0.08^{Z}
Vomiting	0	1 (11.1)	0.06
Regurgitation	4 (12.9)	2 (22.2)	0.49^{Z}
Heart burn	1 (3.2)	2 (22.2)	0.057^{Z}
Bloating	9 (29)	1 (11.1)	0.28^{Z}
Flatulence	7 (22.6)	1 (11.1)	0.45^{Z}
Diarrhea	5 (16.1)	1 (11.1)	0.71^{Z}
Constipation	2 (6.5)	2 (22.2)	0.16^{Z}
Abdominal discomfort/pain	9 (29)	2 (22.2)	0.69^{Z}

χ^2, χ^2 test; %TWL, percentage of total weight loss; GIT, gastrointestinal tract; SIBO, small intestine bacterial overgrowth; *t*, Student *t* test; *U*, Mann–Whitney test; *Z*, *Z* score for proportion.

Discussion

Data on the prevalence of SIBO following OAGB and its implications on the nutritional status are currently scarce. This study assessed patients undergoing OAGB preoperatively and 6 months postoperatively for the potential SIBO development and the thiamine and folic acid status. We selected a cohort that is free of any GIT disease to ensure that the assessed differences would be related to the bariatric procedure as far as possible.

The prevalence found in this study is higher than a recent study that reported a prevalence of 37% after OAGB [17] and another previous study that found 25% increase in the SIBO prevalence after RYGB [19]. We think that this discrepancy in the SIBO prevalence is attributed to the difference in the diagnosis method. The described studies adopted the breath test, whereas in the current study, SIBO identification was based on the culture method, which is the gold standard for diagnosis. Andalib *et al.* [20] and Mouillot *et al.* [21] reported higher prevalence (81 and 83%, respectively). However, both studies assessed only patients with abdominal symptoms. Likewise, the present study revealed that 80% of the patients with abdominal symptoms had SIBO.

The present study presented comparable thiamine and folic acid levels in patients who developed SIBO when compared with those who did have SIBO at the 6-month postoperative follow-up. In contrast with our results, SIBO was reported to be associated with thiamine deficiency and excessive folic acid levels [22,23]. This variance may be attributed to strict adherence to supplementation in the two groups.

The current study showed that patients with SIBO had higher preoperative and postoperative weight measures. In accordance, Roland *et al.*[24] reported significant positive association between obesity and SIBO development. The earlier study of Madrid *et al.* [25] postulated the obesity as a risk factor for SIBO. This could be attributed to the obesity-associated altered bowel motility [26].

In this study, patients who developed SIBO revealed no significant difference in GI symptoms, or the percentage of weight loss compared with patients without SIBO. Similar findings were reported by Kaniel *et al.*[17] in a cohort that underwent OAGB. This may be related, on one hand, to the wide prevalence of GIT disturbance symptoms in patients undergoing OAGB, as OAGB procedure has been described to be considerably hypo-absorptive, even more than RYGB, with higher prevalence of diarrhea and steatorrhea [27], and on the other hand, to that SIBO could be asymptomatic.As for the assessed vitamins levels, the mean thiamine levels were reduced postoperatively compared with the preoperative baseline levels, whereas the mean folate levels were elevated compared with the baseline levels. However, no statistical significance was found. In consistency with our findings, Kaniel *et al.* [17] observed no significant difference in most of the micronutrients levels, including the folate, after OAGB compared with the baseline levels.

The present study showed the remission rates of comorbidities to be comparable to what was previously reported. In the study of Bruzzi *et al.* [28], the remission rates of hypertension and diabetes were 52 and 82%, respectively. Garcia-Caballero and Carbajo [29] found that the resolution rate of type 2 diabetes mellitus was 77% after OAGB. This higher remission rate is likely owing to that the authors assessed the patients 5 and 2 years after OAGB, respectively.

In view of the fact that 48.4% of the patients with SIBO were asymptomatic, the adoption of routine culture study postoperatively could be endorsed. The current study's small sample size, however, affects such recommendation. We highly recommend further larger studies to confirm such issue.

Strength and limitations

The points of strength in this study are the prospective data collection and the use of the gold standard jejunal aspirate culture, for the first time, in diagnosing SIBO after OAGB. However, the study is limited by the relatively small sample size, which was attributed to the difficulty in recruiting patients undergoing OAGB. The study is also limited by the short-term follow-up period.

Conclusion

SIBO was highly prevalent after OAGB (77.5%), with no apparent association with the thiamine or folate levels. The relationship between GIT symptoms and bacterial overgrowth was of no statistical significance, with high incidence of asymptomatic SIBO. OAGB is an effective procedure for weight loss and resolution of comorbidities.

Financial support and sponsorship

Nil.

Conflicts of interest

There are no conflicts of interest.

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