Comparative study between total bowel measurement and proximal bowel measurement in laparoscopic one-anastomosis gastric bypass regarding effect on weight loss and nutritional status

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Background
One-anastomosis gastric bypass (OAGB) is gaining popularity among surgeons for treatment of morbid obesity. Originally, it was comprised of bypassing 200 cm of small bowel, and this produced an incidence of malnutrition of 0.71%. Recent scientific research showed the highly variable length of the human small bowel. In addition, the highest rate of malnutrition was seen with biliopancreatic limb of 250 cm or more. This created a necessity to find more ideal and tailored methods of biliopancreatic limb measurement.
Patients and methods
A prospective randomized study was conducted that included 60 morbidly obese patients who underwent OAGB in the period between January 2019 to January 2021. Patients were randomly assigned into two groups: group A had bypass of 200 cm and group B had total bowel measurement and bypass of one-third of it. They were compared for weight loss and various nutritional parameters.
Results
Excess weight loss (EWL) and mean serum albumin were higher in group B, whereas mean vitamin D level was significantly higher in group A after 6 and 12 months of surgery. No cases of vitamin B1 and B12 were reported during the study period. Mean levels of calcium and iron were insignificantly higher in group B after 6 and 12 months of surgery, but there was no statistically significant difference in nutrient deficiencies between study groups despite a slight advantage for group B.
Conclusion
OAGB with total bowel measurement and bypass of one-third of it produced better weight loss results with less potential for causing malnutrition.

Keywords:
gastric bypass, malnutrition, one-anastomosis gastric bypass, total bowel measurement

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Introduction

Obesity is a health problem of pandemic proportions in world countries of all levels of development. It incurs continually increasing medical care costs in parallel with the increasing disease burden leading to decreased life expectancy, especially among younger individuals [1].

Surgical interference for treatment of morbid obesity has proved to be far superior to pharmacological treatments regarding both weight reduction and resolution of comorbidities like diabetes and hypertension without significant difference in mortality [2].

One-anastomosis gastric bypass (OAGB) surgery has become a well-recognized and practiced bariatric procedure over the past decade. It currently holds the third position among the most performed primary bariatric procedures after sleeve gastrectomy and Roux-en-Y gastric bypass in Europe and Asia [3].

The International Federation for the Surgery of Obesity and Metabolic Disorders (IFSO) in their latest consensus concluded that results from OAGB are promising regarding low rate of perioperative complications, good excess body weight loss, and good improvement of comorbidities such as type 2 diabetes mellitus, hypertension, obstructive sleep apnea, and dyslipidemia and appear at least comparable to other bariatric surgery procedures [4].

In a questionnaire done by the IFSO, there was a staggering difference in all technical aspects of OAGB especially bowel measurements. Only a third of surgeons measured the whole small bowel. Overall,

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29% of them used biliopancreatic limb (BPL) length of 200 cm, 22% used BPL of 150 cm, and others used 180 cm, one-third of total small bowel length, 40–50% of total small bowel length, or a tailored method that uses a formula correlating BMI and body weight to proposed BPL, which was used by 27% of surgeons. These different approaches reflect the obvious gap of knowledge in small bowel dynamics and physiology after bypass surgery [5].

The highest rates of malnutrition of 0.6% were seen by surgeons bypassing a BPL length of more than 250 cm and lowest rates near 0% in the hands of those using a BPL length of 150 cm or less [6].

The total small bowel length is highly variable among individuals. In our review of literature, we found that the shortest length of small bowel was 169 cm as reported by Lohsiriwat *etal*. [7], and the longest was 1510 cm as reported by Raines *etal*. [8]. However, most authors consider a range of 300–900 cm as the accepted range of human small bowel length. It should be noted that a significant number of individuals (3% of females and 2% of males) had total small bowel length less than 400 cm [9].

Originally, Rutledge described using a BPL of 200 cm [10]. Many published trials tried to answer the question about the optimal BPL to use. Most of them recommended using a BPL length of 150 cm in general and 180 cm in the super obese. They generally advised against the use of BPL length more than 200 cm owing to the associated increased nutritional deficiencies [11,12].

Other studies recommended measuring the common channel from the ileocecal valve. However, there was great discrepancy of data and recommendations among them. Some authors recommend leaving at least 300 cm, whereas others recommend leaving at least 400 cm, and even this length cannot guarantee safety from nutritional deficiencies, hence the need for a more comprehensive look [13].

Aim

The aim was to evaluate the outcome of total measurement of bowel and bypass of one-third of it compared with proximal measurement in OAGB surgery regarding effects on weight loss and nutritional status to determine if total measurement of bowel should be adopted as a standard technique.

Patients and methods

This is a prospective randomized study conducted on patients undergoing laparoscopic OAGB surgery using the card selection technique, and patients were randomly fit into one of two groups. Group A had the conventional OAGB with a BPL of 200 cm, and group B had OAGB with measurement of total bowel length and bypass of one-third of it.

The required sample size had been estimated to be 30 patients of each group. A total of 100 patients were initially included in the study, but 21 patients were lost to follow-up, 13 patients refused doing more investigations, and six patients of the second group had difficult total bowel measurement and were not included in our results. Thus, 60 patients were left, who were equally distributed among the two groups of the study design.

This study was conducted at a specialized bariatric unit in a tertiary university hospital in Cairo, Egypt, in the period from January 2019 to January 2021. Approval of the ethical committee and written informed consent from all participants were obtained.

Inclusion criteria

Individuals with morbid obesity eligible for OAGB as the bariatric surgery of choice including patients with BMI more than or equal to 40 or patients with BMI more than or equal to 35 with comorbidities (diabetes or hypertension), patients with no history of bariatric procedures or any other open abdominal surgeries who were undergoing this surgery as their primary bariatric surgery, and patients who are fit for anesthesia without complications (American Society of Anesthesiologists 1 or 2) were included.

Exclusion criteria

Patients who did not fit the inclusion criteria in addition to patients with severe nutritional deficiencies on preoperative assessment that needed to be corrected before surgery or contraindicated surgery at the time, and also, patients with history of uncontrolled psychiatric illness and gastro-esophageal reflux disease were excluded from the study.

All patients included in the study were candidates for the following:

Clinical assessment

Detailed medical, surgical, and family history with careful analysis of symptoms like heartburn, dysphagia was done. Careful assessment of height, weight, BMI, and excess body weight loss before surgery, 6, and

12 months after surgery was also done. Assessment of postoperative satisfaction level, comorbidities, and complications was done.

Investigations

Routine preoperative laboratory investigations with preoperative pelviabdominal ultrasound, pulmonary function tests, chest radiograph, echocardiography, and ECG were done. Preoperative and postoperative laboratory investigations at 6 and 12 months after surgery for serum iron level, total calcium level, serum albumin level, vitamin B1 level, vitamin B12 level, and vitamin D level were also done with other necessary investigations that were not included in the study for certain cases.

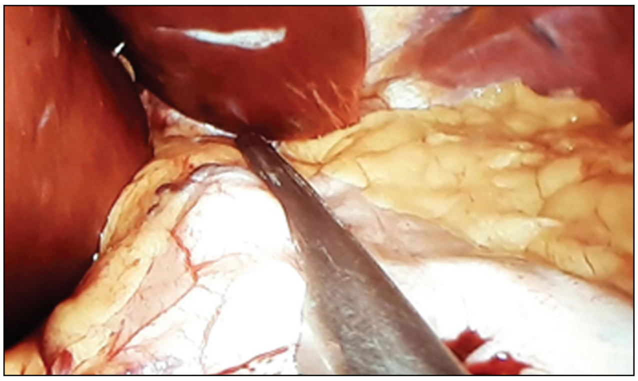
Operative technique

The patient laid in a supine position with both arms extended and legs separated in reverse Trendelenburg position secured with straps. The operator stood between patient's legs with the assistant to the left of the patient and camera man to the right. Access to the abdomen was safely granted by the transparent port technique (Visiport 12 mm, Minneapolis, Minnesota, USA) that was inserted at the midpoint between xiphisternum and symphysis pubis slightly to the left, and then insufflation of the abdomen was done using CO_2 gas to an intra-abdominal pressure of 14 mmHg. A 5-mm port was inserted just below the xiphisternum for liver retraction by an 'S-shaped' retractor. Two 12-mm ports were inserted at the mid-clavicular line to the right and left of the first port closer to the costal margin. Another 5-mm port was inserted in the left hypochondrium for the assistant.

The laparoscopic linear stapler divided the stomach transversely at the junction of the body and antrum just below the crow foot without completely transecting the stomach using a 45-mm cartridge. A calibration tube, of 36-Fr size, was inserted via oral route by the anesthetist and kept against the lesser curve of stomach by the operator. The stapling of the stomach alongside the tube was pursued using a 60-mm stapler, with lines of staples that seal the gastric pouch, thus creating a gastric pouch that was a narrow tube extending from the hiatus caudally to a level at the previous body-antral junction. No short gastric vessels were divided (Fig. 1).

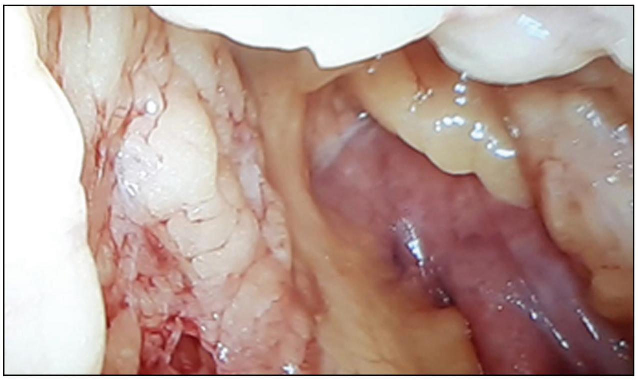
The bypassed stomach lay on the patient's left, and the narrow lesser-curvature gastric pouch lay on the patient's midline to the right of the bypassed stomach. Then, the duodenojejunal flexure was identified by retracting the omentum and transverse mesocolon cranially to reveal the ligament of Treitz (Fig. 2).

Figure 1



Creating the gastric pouch.

Figure 2



Identifying the duodenojejunal flexure and ligament of Treitz.

Group A

The small bowel was measured till a point was reached about 200 cm distal to the ligament of Treitz. The jejunal loop was brought up antecolic, and the linear stapler was used to anastomose the gastric pouch and the small bowel at this point. The inside of the anastomosis was inspected for bleeding before final closure (Fig. 3).

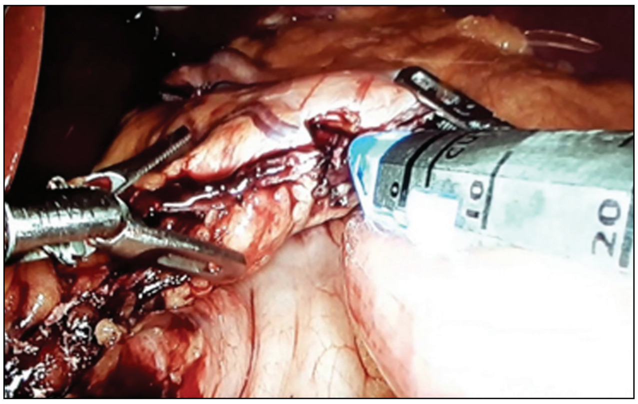
Group B

The whole length of small bowel was measured starting from the ligament of Treitz. The anastomosis was done at a point that divided the small bowel into one-third proximally and two-thirds distally, making BPL that was one-third of total small bowel length (Fig. 4).

All measurements of small bowel were done using atraumatic intestinal graspers. After checking the inside of the anastomosis for bleeding, a Ryle tube was passed nasally by the anesthetist and passed distal to the anastomosis by the surgeon (Fig. 5).

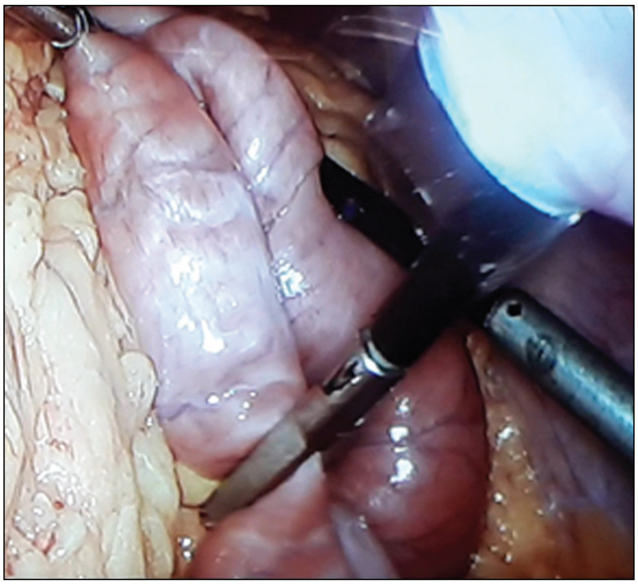
The rest of the anastomosis was then closed by a hand-sewn method using V-loc suture taking care not to

Figure 3



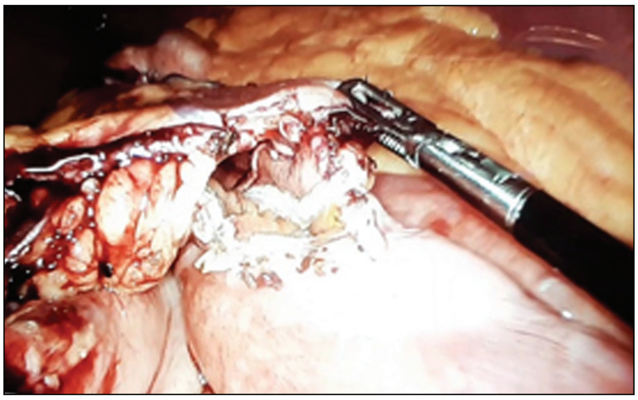
Stapled pouch-jejunal anastomosis.

Figure 4



Measuring the small bowel.

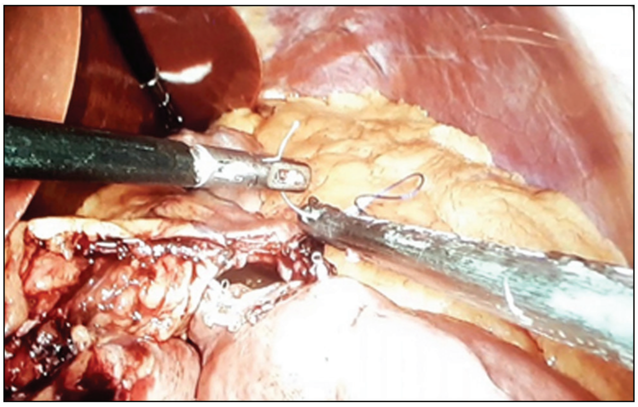
Figure 5



Checking the inside of the anastomosis for bleeding.

anchor the Ryle tube nor the posterior surface of the anastomosis. A leak test using methylene blue dye was done in all cases. Mesenteric defects were closed

Figure 6



Hand-sewn closure of the pouch-jejunal anastomosis.

carefully by a continuous vicryl suture. A tube drain was inserted in all cases (Fig. 6).

Follow-up

All patients of both groups were followed up at regular intervals, and data were recorded at 6 and 12 months. Postoperative multivitamin supplements were prescribed for all patients. The necessary investigations were done for each case as needed in addition to investigations for the study design. Collected data included age, sex, comorbidities, height, preoperative and postoperative weight, and excess body weight loss calculated to an ideal BMI of 25. Recorded investigations included serum levels of iron, calcium, albumin, vitamin B1, vitamin B12, and vitamin D.

Statistical analysis

Data were collected, revised, coded, and entered to the Statistical Package for Social Science (SPSS) version 23 (IBM Corp., Armonk, New York, USA). The quantitative data were presented as mean, SDs, and ranges when data were parametric and median and interquartile range when data were nonparametric. Moreover, qualitative variables were presented as numbers and percentages.

The comparison between groups regarding qualitative data was done using χ^2 test and/or Fisher exact test when the expected count in any cell was found to be less than 5.

The comparison between two groups regarding quantitative data and parametric distribution was done by using independent *t* test, whereas with nonparametric distribution, it was done by using Mann–Whitney test.

The comparison between more than two paired groups regarding quantitative data and parametric distribution was done by using repeated measures analysis of variance test.

The confidence interval was set to 95%, and the margin of error accepted was set to 5%. So, the *P* value was considered significant as follows:

P value more than 0.05: nonsignificant.
P value less than 0.05: significant.
P value less than 0.01: highly significant.

Results

In our study period, we have gathered data about 60 patients who had undergone OAGB. Patients were divided randomly into two groups: one that had the conventional surgery and another group that had total bowel measurement and bypass of one-third of it.

Epidemiological analysis showed that the age of the patients ranged from 21 to 57 years old. Overall, 68.3% of patients were females and 31.7% were males. The prevalence of comorbidities in both groups is also shown in Table 1.

Table1 Age, sex, and comorbidities of study population

	N=60 [*n* (%)]
Age	
Mean±SD	40.42 ± 9.63
Range	21–57
Sex	
Female	41 (68.3)
Male	19 (31.7)
Comorbidities	
No	41 (68.3)
Yes	19 (31.7)
DM	15 (25.0)
HTN	13 (21.7)
OSA	4 (6.7)
RA	1 (1.7)

DM, diabetes mellitus; HTN, hypertension, OSA, obstructive sleep apnea; RA, rheumatoid arthritis.

We found no statistically significant difference between both groups regarding demographic data or presence of comorbidities, thus eliminating any effect of these different variants on the results of the study (Table 2).

When the two groups were compared regarding the preoperative weight, height, BMI, and different laboratory parameters, it was found that all parameters had no statistically significant difference between the two groups apart from the mean preoperative weight, which was slightly higher in the experimental group (*P*=0.049). However, BMI was not significantly different between the two groups of study, as shown in Table 3.

Some patients, however, showed preoperative deficiencies. One patient of group A showed iron deficiency, four patients showed low total calcium levels, and three patients showed low preoperative serum albumin. In group B, two patients had iron deficiency, three patients showed low levels of total calcium, two patients showed hypoalbuminemia, and one patient showed vitamin D deficiency. No patients had vitamin B1 or B12 deficiency. Despite the slight differences between the two groups, they were still statistically nonsignificant (Table 4).

Intraoperative measurements of bowel lengths

The measured total small bowel length in the experimental group ranged from 420 to 920 cm, with mean±SD of 624.66 ± 107.05 cm. The measured biliopancreatic length ranged from 140 to 310 cm, with mean±SD of 208 ± 36.23 cm (Fig. 7).

Table 2 Comparing the two groups regarding age, sex, and comorbidities

	Group A (control group) [*n* (%)] *N*=30	Group B (experimental group) [*n* (%)] *N*=30	Test value	*P* value	Significance
Age					
Mean±SD	39.27 ± 9.75	41.57 ± 9.53	-0.924a	0.359	NS
Range	21–57	24–56			
Sex					
Female	22 (73.3)	19 (63.3)	0.693b	0.405	NS
Male	8 (26.7)	11 (36.7)			
Comorbidities					
No	21 (70.0)	20 (66.7)	0.077b	0.781	NS
Yes	9 (30.0)	10 (33.3)			
DM	8 (26.7)	7 (23.3)	0.089b	0.766	NS
HTN	4 (13.3)	9 (30.0)	2.455b	0.117	NS
OSA	2 (6.7)	2 (6.7)	0.000b	1.000	NS
RA	1 (3.3)	0	1.017b	0.313	NS

DM, diabetes mellitus; HTN, hypertension; OSA, obstructive sleep apnea; RA, rheumatoid arthritis.
[a]Independent *t* test. [b]χ^2 test. *P* value more than 0.05: nonsignificant; *P* value less than 0.05: significant; *P* value less than 0.01: highly significant.

Table 3 Comparing preoperative weight, height, BMI, and laboratory investigations between study groups

Preoperative	Group A (control group) *N*=30	Group B (experimental group) *N*=30	Test value	*P* value	Significance
Weight (kg)					
Mean±SD	144.57±21.43	156.70±25.06	-2.015a	0.049	S
Range	113–179	116–195			
Height (m)					
Mean±SD	165.37±10.16	167.03±10.05	-0.639a	0.525	NS
Range	150–185	149–187			
BMI					
Mean±SD	53.27±9.34	56.50±10.53	-1.258a	0.213	NS
Range	39–79	43–78			
Serum iron (µg/dl)					
Mean±SD	101.03±34.28	103.60±28.81	-0.314a	0.755	NS
Range	47–156	43–150			
Total calcium (mg/dl)					
Mean±SD	9.27±0.67	9.14±0.53	0.854a	0.396	NS
Range	8.2–10.3	8.1–10.1			
Serum albumin					
Mean±SD	4.20±0.70	4.33±0.63	-0.758a	0.452	NS
Range	2.9–5.4	3.1–5.3			
Vitamin B1 (nmol/l)					
Mean±SD	4.81±0.96	5.29±1.01	-1.916a	0.060	NS
Range	3–6.4	3.6–6.8			
Vitamin B12 (pg/ml)					
Mean±SD	647.40±150.02	635.30±187.13	0.276a	0.783	NS
Range	366–850	343–900			
Vitamin D (ng/ml)					
Mean±SD	37.23±9.52	32.57±9.06	1.945a	0.057	NS
Range	20–50	18–48			

[a]Independent *t* test. *P* value more than 0.05: nonsignificant; *P* value less than 0.05: significant; *P* value less than 0.01: highly significant.

Table 4 Comparing preoperative deficiencies in both groups

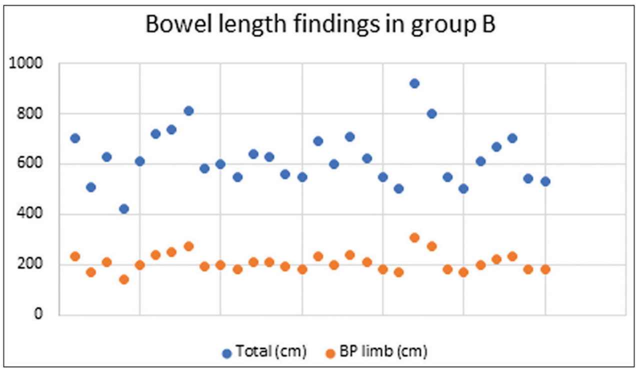
Preoperative	Group A (control group) [*n* (%)] *N*=30	Group B (experimental group) [*n* (%)] *N*=30	Test value	*P* value	Significance
Serum iron					
Deficiency	1 (3.3)	2 (6.7)			
Normal	29 (96.7)	28 (93.3)	0.351a	0.554	NS
Above normal	0	0			
Total calcium					
Below normal	4 (13.3)	3 (10.0)			
Normal	26 (86.7)	27 (90.0)	0.162a	0.688	NS
Above normal	0	0			
Serum albumin					
Below normal	3 (10.0)	2 (6.7)			
Normal	27 (90.0)	28 (93.3)	0.218a	0.640	NS
Above normal	0	0			
Vitamin B1					
Deficiency	0	0			
Normal	30 (100.0)	30 (100.0)	–	–	–
Above normal	0	0			
Vitamin B12					
Deficiency	0	0			
Normal	30 (100.0)	30 (100.0)	–	–	–
Above normal	0	0			
Vitamin D					
Deficiency	0	1 (3.3)			NS
Normal	30 (100.0)	29 (96.7)	1.017a	0.313	
Above normal	0	0			

[a]χ^2 test. *P* value more than 0.05: nonsignificant; *P* value less than 0.05: significant; *P* value less than 0.01: highly significant.

After 6 months of surgery

When we compared the two groups regarding weight after 6 months of surgery, group B had slightly higher mean weight and mean BMI than group A but with no statistically significant difference. This can be explained by the higher mean body weight and BMI that was observed preoperatively in group B than in group A. However, %EWL was significantly higher in group B than in group A. Concerning laboratory results, the mean serum iron, total calcium, and vitamin B1 were slightly higher in group B but not statistically significant. Mean vitamin B12 level was higher in group A but also statistically nonsignificant. Mean serum albumin level was significantly higher in group B than in group A (P=0.017), indicating better overall nutritional status. Mean vitamin D was, on the contrary, significantly higher in group A than in group B (Table 5).

Figure 7



Measured small bowel lengths in experimental group.

Despite the previous results, there was no statistically significant difference in deficiencies after 6 months between study groups. No deficiency in vitamin B1 or B12 was reported. However, it is still worth mentioning that numbers of patients who had serum iron, total calcium, serum albumin, and vitamin D deficiencies were higher in group A than in group B. Overall, 13.3% of patients in group A had above-normal levels of vitamin D, which may be attributed to vitamin supplements (Table 6).

After 1 year of surgery

Patients of both groups were followed up, and the results were reported for the 1-year mark after surgery. Like the 6-month mark, patients of group B

Table 5 Comparing the two study groups after 6 months

6 months postoperative	Group A (control group) *N*=30	Group B (experimental group) *N*=30	Test value	*P* value	Significance
Weight (kg)					
Mean±SD	98.77±11.64	100.77±11.57	-0.668a	0.507	NS
Range	79–122	82–124			
BMI					
Mean±SD	35.63±4.16	36.20±4.11	-0.531a	0.598	NS
Range	31–49	30–47			
%EBWL					
Mean±SD	60.17±2.94	64.07±3.49	-4.681a	0.000	HS
Range	55–65	58–68			
Serum iron (μg/dl)					
Mean±SD	89.93±29.18	101.00±27.59	-1.509a	0.137	NS
Range	43–136	53–159			
Total calcium (mg/dl)					
Mean±SD	8.80±0.73	9.01±0.60	-1.256a	0.214	NS
Range	7.7–10.8	7.6–10.3			
Serum albumin					
Mean±SD	4.05±0.56	4.45±0.68	-2.458a	0.017	S
Range	2.7–5.2	3.3–5.8			
Vitamin B1 (nmol/l)					
Mean±SD	4.88±1.09	4.95±0.90	-0.296a	0.768	NS
Range	3.2–7	3.4–6.6			
Vitamin B12 (pg/ml)					
Mean±SD	659.40±155.83	574.10±180.38	1.960a	0.055	NS
Range	358–858	284–865			
Vitamin D (ng/ml)					
Mean±SD	39.77±11.36	32.80±8.82	2.652a	0.010	S
Range	19–58	21–50			

[a]Independent *t* test. *P* value more than 0.05: nonsignificant; *P* value less than 0.05: significant; *P* value less than 0.01: highly significant.

Table 6 Comparing deficiencies between study groups after 6 months of surgery

6 months postoperative	Group A (control group) [*n* (%)] *N*=30	Group B (experimental group) [*n* (%)] *N*=30	Test value	*P* value	Significance
Serum iron					
Deficiency	3 (10.0)	2 (6.7)			
Normal	27 (90.0)	28 (93.3)	0.218a	0.640	NS
Above normal	0	0			
Total calcium					
Below normal	12 (40.0)	6 (20.0)			
Normal	17 (56.7)	24 (80.0)	4.195a	0.123	NS
Above normal	1 (3.3)	0			
Serum albumin					
Below normal	2 (6.7)	1 (3.3)			
Normal	28 (93.3)	26 (86.7)	3.407a	0.182	NS
Above normal	0	3 (10.0)			
Vitamin B1					
Deficiency	0	0			
Normal	30 (100.0)	30 (100.0)	–	–	–
Above normal	0	0			
Vitamin B12					
Deficiency	0	0			
Normal	30 (100.0)	30 (100.0)	–	–	–
Above normal	0	0			
Vitamin D					
Deficiency	1 (3.3)	0			
Normal	25 (83.3)	30 (100.0)	5.455a	0.065	NS
Above normal	4 (13.3)	0			

[a]χ^2 test. *P* value more than 0.05: nonsignificant; *P* value less than 0.05: significant; *P* value less than 0.01: highly significant.

had slightly higher mean weight and BMI, with no statistically significant difference. Surprisingly, patients of group A caught up with group B in %EWL, with the advantage still in favor of group B but with no statistically significant difference. After 1 year of surgery, the mean levels of serum iron, total calcium, and vitamin B1 remained higher in group B but still with no statistically significant difference. Mean level of vitamin B12 was higher in group A but was also not statistically significant. A statistically significant difference was noted in the mean levels of serum albumin and vitamin D. Mean level of serum albumin was significantly higher in group B, but the mean level of vitamin D was significantly higher in group A (Table 7).

The incidence of deficiency of serum iron, total calcium, serum albumin, and vitamin D was slightly higher in group A after 1 year of surgery but with no statistical significance. Over the whole study period, no cases of vitamin B1 or B12 deficiency were reported among the study population (Table 8).

Trends of change with time

Table 9 shows the results of comparing the percentage and direction of change for each of the investigated items between the two study groups after 6 months of surgery.

Similar change patterns can be seen after 1 year of surgery, but the only statistically significant change is the change in serum albumin, which is much better in group B than in group A (Table 10).

Change patterns were also analyzed for the individual groups in relation to time, and significant changes were noted for all study population that underwent OAGB whether by the traditional method or by bypassing one-third of the small bowel. Tables 11 and 12 and Figs 8–15 show these change patterns.

Discussion

Obesity is a growing problem in this modern age. Sedentary lifestyle with unhealthy eating habits together with many genetic and environmental factors have largely contributed to the rise of morbid obesity.

Surgical treatment of obesity has proven to be the most effective treatment so far [2]. Many restrictive and malabsorptive procedures have emerged over the years to achieve weight loss and improve comorbidities without serious adverse effects.

The use of OAGB is on the rise considering the ease of operating, shorter hospital stay, and lower cost together with excellent weight loss results and

Table 7 Comparing the two study groups after 1 year of surgery

1 year postoperative	Group A (control group) *N*=30	Group B (experimental group) *N*=30	Test value	*P* value	Significance
Weight (kg)					
Mean±SD	87.53±9.13	90.63±10.65	-1.210a	0.231	NS
Range	73–107	69–111			
BMI					
Mean±SD	31.53±2.65	32.50±3.25	-1.264a	0.211	NS
Range	28–38	29–40			
%EBWL					
Mean±SD	74.57±4.38	76.10±4.82	-1.290a	0.202	NS
Range	67–81	69–84			
Serum iron (μg/dl)					
Mean±SD	87.90±28.37	89.00±25.05	-0.159a	0.874	NS
Range	42–134	42–146			
Total calcium (mg/dl)					
Mean±SD	8.53±0.57	8.71±0.63	-1.138a	0.260	NS
Range	7.4–10	7.2–10.2			
Serum albumin					
Mean±SD	3.94±0.53	4.34±0.64	-2.634a	0.011	S
Range	2.4–4.9	3.2–5.6			
Vitamin B1 (nmol/l)					
Mean±SD	4.60±1.05	4.68±0.83	-0.341a	0.734	NS
Range	2.9–6.4	3.1–6			
Vitamin B12 (pg/ml)					
Mean±SD	606.03±155.81	578.47±186.32	0.622a	0.537	NS
Range	250–806	262–905			
Vitamin D (ng/ml)					
Mean±SD	41.93±16.31	32.93±9.21	2.633a	0.011	S
Range	15–79	18–55			

[a]Independent *t* test. *P* value more than 0.05: nonsignificant; *P* value less than 0.05: significant; *P* value less than 0.01: highly significant.

Table 8 Comparing deficiencies among study groups after 1 year of surgery

1 year postoperative	Group A (control group) [*n* (%)] *N*=30	Group B (experimental group) [*n* (%)] *N*=30	Test value	*P* value	Significance
Serum iron					
Deficiency	4 (13.3)	3 (10.0)			
Normal	26 (86.7)	27 (90.0)	0.162a	0.688	NS
Above normal	0	0			
Total calcium					
Below normal	12 (40.0)	10 (33.3)			
Normal	18 (60.0)	20 (66.7)	0.287a	0.592	NS
Above normal	0	0			
Serum albumin					
Below normal	3 (10.0)	1 (3.3)			
Normal	27 (90.0)	27 (90.0)	3.000a	0.223	NS
Above normal	0	2 (6.7)			
Vitamin B1					
Deficiency	0	0			
Normal	30 (100.0)	30 (100.0)	–	–	–
Above normal	0	0			
Vitamin B12					
Deficiency	0	0			
Normal	30 (100.0)	30 (100.0)	–	–	–
Above normal	0	0			
Vitamin D					
Deficiency	4 (13.3)	2 (6.7)			
Normal	20 (66.7)	27 (90.0)	5.281a	0.071	NS
Above normal	6 (20.0)	1 (3.3)			

[a]χ^2 test. *P* value more than 0.05: nonsignificant; *P* value less than 0.05: significant; *P* value less than 0.01: highly significant.

Table 9 Percentage of change after 6 months compared between study groups

% of change after 6 months	Group A (control group) *N*=30	Group B (experimental group) *N*=30	Test value	*P* value	Significance
Weight (kg)					
Mean±SD	-31.26±4.74	-35.08±5.32	-2.551a	0.011	S
Range	-40 to -20.35	-46.15 to -26.77			
BMI					
Mean±SD	-32.41±4.69	-35.09±5.15	-1.782a	0.075	NS
Range	-41.18 to -20.51	-46.05 to -26.67			
Serum iron (μg/dl)					
Mean±SD	-10.23±6.36	-1.06±15.26	-2.972a	0.003	HS
Range	-18.92 to 6.15	-20.9 to 58.14			
Total calcium (mg/dl)					
Mean±SD	-4.99±5.98	-1.30±4.56	-2.602a	0.009	HS
Range	-14.71 to 5.38	-13.86 to 5.56			
Serum albumin					
Mean±SD	-2.09±14.35	2.76±5.39	-2.429a	0.015	S
Range	-24 to 37.93	-5 to 10.26			
Vit. B1 (nmol/l)					
Mean±SD	1.76±12.84	-5.77±9.28	-2.602a	0.009	HS
Range	-20.31 to 20.75	-20.93 to 10.91			
Vitamin B12 (pg/ml)					
Mean±SD	1.78±2.66	-9.58±10.29	-4.288a	0.000	HS
Range	-3.11 to 4.96	-27.03 to 10			
Vitamin D (ng/ml)					
Mean±SD	6.40±12.79	1.71±10.20	-1.215a	0.224	NS
Range	-13.64 to 37.5	-14.71 to 22.22			

[a]Mann–Whitney test. *P* value more than 0.05: nonsignificant; *P* value less than 0.05: significant; *P* value less than 0.01: highly significant.

Table 10 Percentage of change after 1 year of surgery compared between study groups

% of change after 1 y	Group A (control group) *N*=30	Group B (experimental group) *N*=30	Test value	*P* value	Significance
Weight (kg)					
Mean±SD	-38.79±6.43	-41.50±6.16	-1.567a	0.117	NS
Range	-51.69 to -27.43	-56.91 to -30.17			
BMI					
Mean±SD	-39.84±6.18	-41.50±6.18	-1.013a	0.311	NS
Range	-51.9 to -28.21	-57.14 to -30.23			
Serum iron (μg/dl)					
Mean±SD	-12.24±5.85	-12.46±16.74	-0.517a	0.605	NS
Range	-20.8 to 2.82	-37.31 to 51.16			
Total calcium (mg/dl)					
Mean±SD	-7.68±6.74	-4.66±4.35	-1.767a	0.077	NS
Range	-19.61 to 7.32	-13.86 to 4.12			
Serum albumin					
Mean±SD	-4.56±16.10	0.39±6.02	-2.472a	0.013	S
Range	-31.43 to 37.93	-10 to 12.9			
Vitamin B1 (nmol/l)					
Mean±SD	-3.92±13.77	-10.58±12.02	-1.929a	0.054	NS
Range	-28.13 to 18.87	-31.03 to 16.67			
Vitamin B12 (pg/ml)					
Mean±SD	-6.91±6.91	-9.18±11.38	-0.991a	0.322	NS
Range	-40.33 to -0.46	-27.78 to 10.17			
Vitamin D (ng/ml)					
Mean±SD	11.45±31.24	2.15±13.41	-0.347a	0.728	NS
Range	-42.31–87.5	-23.53–26.67			

[a]Mann–Whitney test. *P* value more than 0.05: nonsignificant; *P* value less than 0.05: significant; *P* value less than 0.01: highly significant.

Table 11 Analysis of changes in patients of group A over time

	Group A (control group)			Test value	*P* value	Significance
	Pre	6 months	1 year			
Weight (kg)						
Mean±SD	144.57 ± 21.43	98.77 ± 11.64	87.53 ± 9.13	358.485a	<0.001	HS
Range	113–179	79–122	73–107			
BMI						
Mean±SD	53.27 ± 9.34	35.63 ± 4.16	31.53 ± 2.65	282.092a	<0.001	HS
Range	39–79	31–49	28–38			
Serum iron (μg/dl)						
Mean±SD	101.03 ± 34.28	89.93 ± 29.18	87.90 ± 28.37	78.923a	<0.001	HS
Range	47–156	43–136	42–134			
Total calcium (mg/dl)						
Mean±SD	9.27 ± 0.67	8.80 ± 0.73	8.53 ± 0.57	25.596a	<0.001	HS
Range	8.2–10.3	7.7–10.8	7.4–10			
Serum albumin						
Mean±SD	4.20 ± 0.70	4.05 ± 0.56	3.94 ± 0.53	4.408a	0.039	S
Range	2.9–5.4	2.7–5.2	2.4–4.9			
Vitamin B1 (nmol/l)						
Mean±SD	4.81 ± 0.96	4.88 ± 1.09	4.60 ± 1.05	3.920a	0.054	NS
Range	3–6.4	3.2–7	2.9–6.4			
Vitamin B12 (pg/ml)						
Mean±SD	647.40 ± 150.02	659.40 ± 155.83	606.03 ± 155.81	77.528a	<0.001	HS
Range	366–850	358–858	250–806			
Vitamin D (ng/ml)						
Mean±SD	37.23 ± 9.52	39.77 ± 11.36	41.93 ± 16.31	4.420a	0.041	S
Range	20–50	19–58	15–79			
Post-hoc analysis						
	Pre vs. 6 months		Pre vs. 1 year		6 months vs. 1 year	
Weight (kg)	<0.001		<0.001		<0.001	
BMI	<0.001		<0.001		<0.001	
Serum iron (μg/dl)	<0.001		<0.001		<0.001	
Total calcium (mg/dl)	<0.001		<0.001		0.015	
Serum albumin	0.455		0.076		0.005	
Vitamin B12 (pg/ml)	0.002		<0.001		<0.001	
Vitamin D (ng/ml)	0.022		0.116		0.417	

P value more than 0.05: nonsignificant; *P* value less than 0.05: significant; *P* value less than 0.01: highly significant. [a]Repeated Measures analysis of variance test.

metabolic benefits compared with the more standard Roux-en-Y gastric bypass [14]. It is considered a partly restrictive, partly malabsorptive procedure. However, this concept of mechanism of weight loss in bariatric surgeries is changing nowadays with the discovery of gut hormones and their influence on the outcome of bariatric surgeries [15].

Many studies have shown that OAGB has similar safety and efficacy to Roux-en-Y gastric bypass with even better results sometimes. This was acknowledged by the scientific society and the IFSO in their latest consensus agreement about the procedure [4].

The technical basics of the surgery is to create a long narrow gastric pouch and anastomosing it to a loop of jejunum 200 cm away from the ligament of Treitz [10]. The length of the BPL has been a subject of debate in the last decade. This debate extended from similar controversy about limb lengths in Roux-en-Y gastric bypass [16]. The object of controversy is whether 200 cm is the ideal limb length to achieve optimum weight loss and avoid nutritional deficiencies or not [9].

Up till now, there is no standardization of the used limb lengths in OAGB. Different surgeons from different parts of the world use different methods. There is still a gap of knowledge in this regard, and extensive research is needed to determine the optimal BPL length [9].

The total length of human small bowel is greatly variable. Most studies consider the accepted range to be between 300 and 900 cm [9]. However, some papers reported bowel lengths as short as 169 cm [7] and as long as 1510 cm [8]. This creates a serious risk if a BPL length of 200 cm is used in an individual with short bowel, creating malnutrition and excessive

Table 12 Analysis of changes in patients of group B over time

	Group B (experimental group)			Test value	*P* value	Significance
	Pre	6 months	1 year			
Weight (kg)						
Mean±SD	156.70±25.06	100.77±11.57	90.63±10.65	350.750a	<0.001	HS
Range	116–195	82–124	69–111			
BMI						
Mean±SD	56.50±10.53	36.20±4.11	32.50±3.25	260.584a	<0.001	HS
Range	43–78	30–47	29–40			
Serum iron (µg/dl)						
Mean±SD	103.60±28.81	101.00±27.59	89.00±25.05	25.681a	<0.001	HS
Range	43–150	53–159	42–146			
Total calcium (mg/dl)						
Mean±SD	9.14±0.53	9.01±0.60	8.71±0.63	22.189a	<0.001	HS
Range	8.1–10.1	7.6–10.3	7.2–10.2			
Serum albumin						
Mean±SD	4.33±0.63	4.45±0.68	4.34±0.64	5.558a	0.017	S
Range	3.1–5.3	3.3–5.8	3.2–5.6			
Vitamin B1 (nmol/l)						
Mean±SD	5.29±1.01	4.95±0.90	4.68±0.83	19.143a	<0.001	HS
Range	3.6–6.8	3.4–6.6	3.1–6			
Vitamin B12 (pg/ml)						
Mean±SD	635.30±187.13	574.10±180.38	578.47±186.32	15.202a	<0.001	HS
Range	343–900	284–865	262–905			
Vitamin. D (ng/ml)						
Mean±SD	32.57±9.06	32.80±8.82	32.93±9.21	0.177a	0.762	NS
Range	18–48	21–50	18–55			
Post-hoc analysis						
	Pre vs. 6 months		Pre vs. 1 year		6 months vs. 1 year	
Weight (kg)	<0.001		<0.001		<0.001	
BMI	<0.001		<0.001		<0.001	
Serum iron (µg/dl)	0.774		<0.001		<0.001	
Total calcium (mg/dl)	0.376		<0.001		<0.001	
Serum albumin	0.037		1.000		<0.001	
Vitamin B1 (nmol/l)	0.004		<0.001		0.007	
Vitamin B12 (pg/ml)	0.001		0.002		1.000	

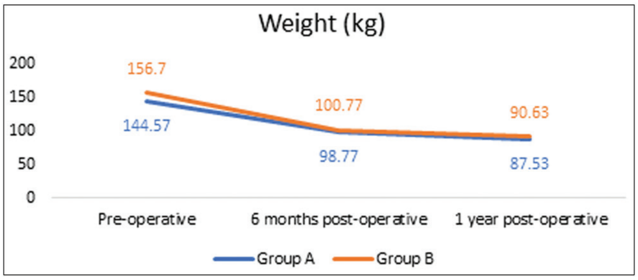
P value more than 0.05: nonsignificant; *P* value less than 0.05: significant; *P* value less than 0.01: highly significant. [a]Repeated Measures analysis of variance test.

weight loss, which may lead to mortality. It can also cause failure of proper weight loss in an individual with long bowel. Total small bowel length was found to be only correlated with individual's height with no regard to weight or sex [17]. It was also found that different methods of measuring the small bowel can produce different results in the same individual as the bowel is stretchable and is affected by many factors like cold or anesthesia [16].This was a subject of extensive research that studied using BPL lengths of 150, 180, 200, and 250 cm, or using a formula that correlates different preoperative anthropometric measures to the proposed BPL length [13,18]. Many studies also recommended measuring the common channel distally and others recommended measuring the total bowel length and creating a BPL length that is one-third or 40% of the total small bowel length [19,20].

Concluding all those studies, the best fixed BPL length appears to be 150–180 cm. However, measuring the whole bowel produced more operative time but also the best outcome regarding weight loss and lowering the risk for nutritional complications [11,12].

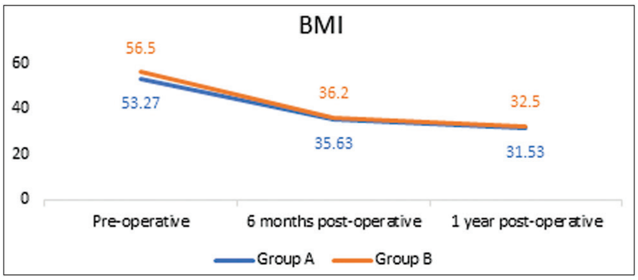
In our study, we assessed the difference that could be obtained from measuring the whole small bowel and bypass of one-third of it. The study was done at a single university hospital in Cairo, Egypt. We randomized the patients into two groups: the first group had the conventional OAGB using a fixed BPL length of 200 cm and the second group had their total small bowel measured and recorded and one-third of it was bypassed. Patients were followed up at regular intervals, and the results were recorded at 6 and 12 months after surgery. The two groups were compared regarding %EWL and different nutritional parameters such as

Figure 8



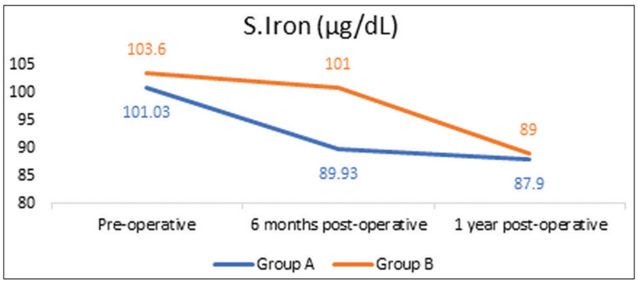
Change pattern in weight over time for study groups.

Figure 9



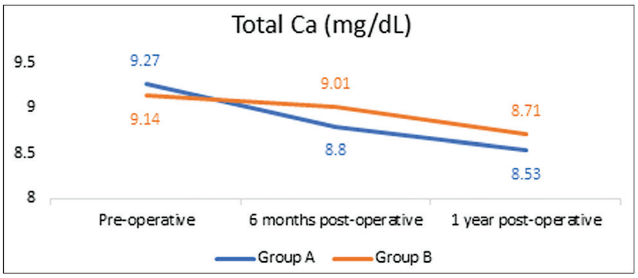
Change pattern in BMI over time for study groups.

Figure 10



Change pattern in serum iron over time for study groups.

Figure 11

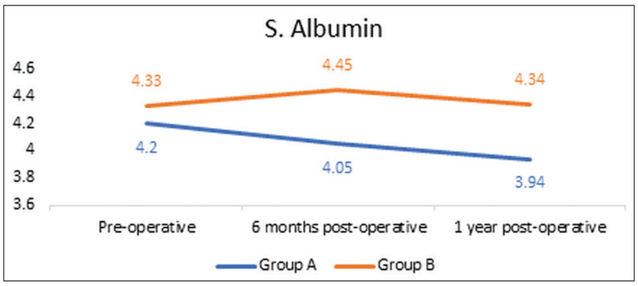


Change pattern in total calcium over time for study groups.

serum iron, total calcium level, serum albumin level, vitamin B1 level, vitamin B12 level, and vitamin D level.

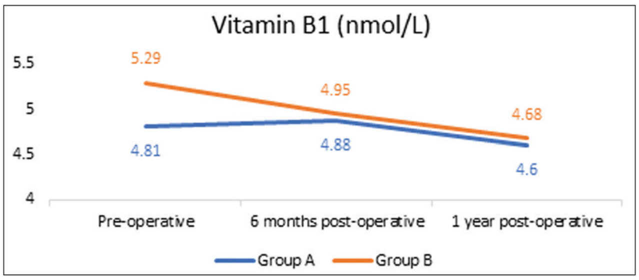
The included individuals in our study ranged in age between 21 and 57 years old, with a mean age of 40.42 years. About two-thirds of our study population

Figure 12



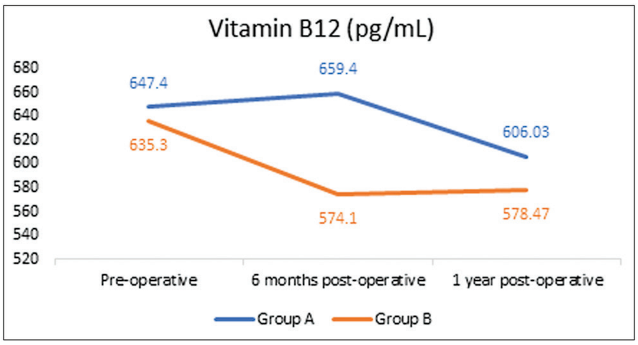
Change pattern in serum albumin over time for study groups.

Figure 13



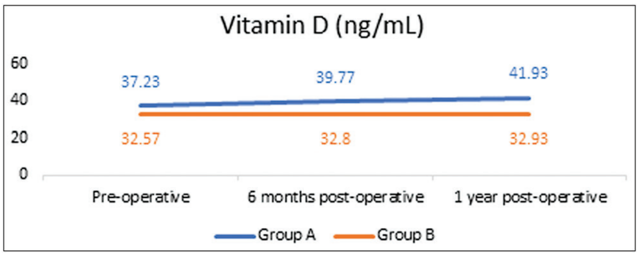
Change pattern in vitamin B1 level over time for study groups.

Figure 14



Change pattern in vitamin B12 level over time for study groups.

Figure 15



Change pattern in vitamin D level over time for study groups.

were females (68.3%). Most of them had no comorbidities. Of those who had comorbidities, 25% had diabetes and 21.7% had hypertension. Overall, 8.4% had other comorbidities like obstructive sleep apnea and rheumatoid arthritis.

Comparing both study groups regarding those demographic data revealed that there was no statistically significant difference in the distribution of age, sex, and having different comorbidities, thus reassuring of the negligible effect these differences can have on the results of the study.

Moreover, when we compared weight, height, BMI, and laboratory investigations before surgery, we found no statistically significant difference between study groups apart from mean preoperative weight, which was higher in the experimental group.

The measured bowel lengths obtained intraoperatively in the group that had total bowel measurement ranged from 420 to 920 cm, with a mean value of 624.66 cm, for the total small bowel length. The measured biliopancreatic length ranged from 140 to 310 cm, with a mean value of 208 cm.

The early results of our study revealed significant advantage for patients who had total bowel measurement in percentage of excess body weight loss and serum albumin levels after 6 months of surgery despite higher mean body weight and BMI for the same group. This can be explained as this group had higher preoperative weight and BMI but still had better overall weight loss than patients who had the conventional surgery. Moreover, higher levels of serum albumin indicate better overall protein nutritional status.

This trend continued to show up after 1 year of surgery, but the difference in weight loss became less significant between both groups but still in favor of the group that had total bowel measurement. The mean %EWL for the control group was 74.57 ± 4.38 vs. 76.10 ± 4.82 for the experimental group after 1 year. The highest recorded percentage of EWL was seen in a patient from the experimental group and reached 84 versus 81% for the control group. We can conclude from these results that patients who had bypass of one-third of the small bowel had better weight loss in the shorter term, but both groups had similar results after 1 year.

Regarding various nutritional parameters, mean serum iron was slightly higher in the group where total bowel measurement had taken place after 6 months and 1 year of surgery but with no statistical significance. Overall, patients of the control group had more reduction in mean serum iron level after 6 months but similar to the other group after 1 year. Although more patients had iron deficiency of the experimental group before surgery, this was reversed after surgery as we found more patients of the control group experiencing iron deficiency after 6 and 12 months postoperatively. However, the difference in deficiency was also not statistically significant.

Similar observations can be seen regarding the total calcium level. The number of patients with low levels of calcium was higher in the control group after 6 and 12 months of surgery but with no statistically significant difference. A clear significant difference can be seen in the change pattern of total calcium as it dropped much more in the control group than in the experimental group, but this trend was not as significant in the 1-year mark.

No reported cases of vitamin B1 or B12 deficiency were seen in our study. This clearly points to the rarity of these deficiencies despite the devastation they may cause when they do occur. However, we found that levels of these vitamins were much better in the control group with less deterioration than the other group. This may be explained by better adherence to vitamin supplements.

Surprisingly, levels of vitamin D were higher in the control group especially after 1 year when they had statistically significant advantage over the experimental group. Moreover, the control group had higher elevation of mean vitamin D levels compared with the experimental group and compared with the preoperative levels. However, more cases with vitamin D deficiency were seen in the control group. In light of this conflicting evidence and taking into account the reduction of total calcium that occurred to this study group, this may be explained by the higher doses of vitamin D supplement needed in this group that suffered more from low calcium levels.

We also analyzed the change patterns within each of the two groups, and it was clearly evident that OAGB in both of them had a profound effect on the whole nutritional status of an individual. There were significant changes in all measured parameters over the study period.

By comparing the percentage and direction of change for each of the investigated items between the two study groups, we found that most of them had statistically significant difference. Loss of weight was significantly better in the experimental group after 6 months, whereas loss of BMI was not significantly better. Serum iron, total calcium, and serum albumin had more downward change in the control group than in the experimental group after 6 months, whereas vitamins B1, B12, and D had overall improvement in the control group with change in vitamin D being the only one of them that was statistically insignificant. Similar change patterns can be seen after 1 year of surgery, but the only statistically significant change is the change in serum albumin, which is much better in the experimental group than in the control group.

In our study, we found strong evidence supporting the measurement of total bowel length and bypass of one-third of it as a better surgical technique than measuring a fixed 200-cm BPL. It produced better overall weight loss and less nutritional deficiencies. More studies are needed in this regard with a larger sample size to prove the advantage of such technique and to support the standard use of it in OAGB surgery.

Conclusion

We found that measuring the whole small bowel and bypass of one-third of it produced better weight loss and less nutritional complications than the conventional method. More studies need to investigate this technique as a potential standard technique for OAGB instead of the conventional one.

Limitations of study

Limitations include the small sample size and short follow-up period. More studies with larger sample size and longer follow-up periods are needed.

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Nil.

Conflicts of interest

None.

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