EJONS International Journal on Mathematic, Engineering and Natural Sciences | ISSN 2602 - 4136

Article Arrival Date: 22.06.2023 | Article Type: Research Article | Article Published Date: 20.09.2023

THE CALCULATION OF IDEAL BILIOPANCREATIC LIMB LENGTH IN ONE ANASTOMOSIS OR MINI-GASTRIC BYPASS PROCEDURE

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ABSTRACT

Objective: Excessive weight loss, malnutrition, and protein malnutrition are considered serious problems in the One Anastomosis or Mini Gastric Bypass (OA-MGB) Procedure. The purpose of the present study was to show whether the Ideal BPL calculated over this length by measuring the length of the small intestine can be a solution to these problems in the 180-200 cm standard BPL.

Methods: A total of 1267 patients who were treated with the OA-MGB method in obesity management were included in the study. The patients were divided into two groups and the length of the small intestine was calculated. One-third of the small intestine was determined as Ideal BPL (Group 1, n=667). Those with BPL 180-200 cm as standard formed group 2 (n=600) without taking into account the length of the small intestine. The patients were followed for 3.4±1.6 years in the study. Weight loss, micronutrients, protein and electrolyte values, clinical and laboratory results, and complications were analyzed in the patients.

Results: In the present study, diarrhea, constipation, malodorous and greasy stool, excessive weight loss, dumping, and protein malnutrition scores were found to be statistically higher in the standard BPL group. The postoperative laboratory markers were statistically significantly higher in the Ideal BPL group than in the standard BPL group ($p<0.05$) and secondary elevation of parathormone was higher in the standard BPL group.

Conclusion: As a result of the study, nutritional deficiency and protein malnutrition detected in the OA-MGB procedure were not observed in the Ideal BPL group. The study also found that the Ideal BPL length was superior to standard BPL with fewer micronutrient, electrolyte, and protein deficiencies when providing similar weight loss and metabolic remission results.

Keywords: One anastomosis or mini-gastric bypass; Small bowel measurement; Ideal biliopancreatic limb length.

INTRODUCTION

One Anastomosis or Mini Gastric Bypass (OA-MGB) is used widely in obesity treatment in the world in recent years (1). Mini-Gastric bypass (MGB) was first introduced by Rutledge (2). The

International Federation for Surgery of Obesity and Metabolic Disorders named it One Anastomosis Gastric Bypass-Mini Gastric Bypass (OAGB-MGB) in our present day. It is a bariatric surgery procedure that is accepted widely by bariatric surgeons worldwide (3). This procedure is an annular anastomosis of the ilium attached to the gastric pouch based on a long and vertical less curvature. The standard biliopancreatic limb length (BPL) is 180-200 cm (4).

Successful weight loss, very low and manageable complications, low comorbidities related to the surgery, significant effects on lifestyle, very low weight gain, and being convertible are indications of the OA-MGB procedure that it is a good alternative to other procedures (5-6). This procedure is effective with the restrictive and malabsorptive mechanisms (7). It seems that the higher malabsorption effect in OA-MGB occurs because of longer BPL (8). The bypassed limb length and its effects are controversial in this procedure.

Many previous studies published weight loss results of the OA-MGB procedure with fixed BPL (9). Some studies suggested adapting BPL according to some factors such as Body Mass Index (BMI) (10). Other studies, on the other hand, emphasized that BPL has no effects on weight loss, especially in patients who were not morbidly obese (11). BPL length in the OA-MGB procedure is controversial and there is no consensus on the Ideal BPL length. The purpose of the present study was to calculate the Ideal BPL length by measuring the length of the small intestine to achieve ideal weight loss and a permanent metabolic remission and to protect patients from malnutrition and other comorbidities.

MATERIALS AND METHODS

A total of 1267 patients who were treated with bariatric and metabolic surgery in the management of obesity in the general surgery clinic of our hospital between March 2015 and January 2022 were included in the study. The demographic characteristics of the patients and their clinical and biochemical data were collected from imaging reports, patient files, and electronic records. The patients were divided into two groups. In this study, the length of the small intestine was calculated firstly (Image 1). One-third of the small intestine was determined as the Ideal **BPL**. This Ideal BPL was Group 1. Those with a standard BPL length of 180-200 cm formed Group 2 without considering the small intestine length. A ~2.5 cm-long gastroenteric anastomosis line was created between the biliopancreatic limb and the common canal in the groups (Image 2). The data of 1267 patients who underwent the OA-MGB procedure (Picture 3) were analyzed in the study. Weight loss results, micronutrient, albumin, and electrolyte values, clinical and laboratory results, and complications were analyzed in these patients. The study was conducted with the approval of Medicana International Samsun Hospital Clinical Research Ethics Committee (08.06.2022-08) and in line with ethical rules.

Approximately 250 OA-MNG surgical procedures are performed in our clinic on an annual scale. The study included those who were obese (Class III, BMI ≥40 kg/m^2), in the presence of any obesity-related comorbidity (such as Type 2 Diabetes Mellitus (DM2), hypertension, hyperlipidemia, obstructive sleep apnea) (Class II, BMI ≥35 kg/m^2) between the ages of 18 and 65, who could not lose weight with diet and exercise for 1 year, who were ready to change the lifestyle after the surgery, mentally and physically.

Those who were Class I obese and weaker, cancer patients, bleeding diathesis, those who had undergone any bariatric surgical procedure before, those with lung, kidney, and liver failure, and those who were not ready for the diet and nutrition recommended after the surgery, those under the age of 18 and those over the age of 65 were not included in the study.

The weight, Body Mass Index (BMI), and total weight loss of the patients were calculated in the preoperative and postoperative 3.4±1.6 years. Postoperative complications were recorded from the hospital database. Laboratory data as hemoglobin (cut-off level 12-17.2 g/dL), serum iron (cut-off level 12-150 ng/mL), total iron binding capacity (cut-off level 240-450 ug/dL), ferritin (cut-off level

20-500 ml/ng), fasting plasma glucose (cut-off level 70-100 mg/dL), hemoglobin A1c (cut-off level 4.7-5.6%), albumin (cut-off level 3.4- 5.4 g/dL), calcium (cut-off level 8.5- 10.3 mg/dL), phosphorus (cut-off level 2.5-4.5 mg/dL), parathormone (cut-off level 15-65pg/mL), triglyceride (cut-off level 0-150 mg/dL), low density lipoprotein cholesterol (cut-off level 130-159 mg/dL, LDL-C), ALT (cut-off level 0-41 U/L), 25-OH D Vitamin (cut-off level 30-50 ng/mL), vitamin B12 (cut-off level 200-300 pg/mL) values were evaluated preoperatively and post-operatively at 3.4±1.6 years. These data were obtained by using the Roche Hitachi 912 Chemistry Analyzer.

Patients were given proton pump inhibitors, sucralfate (first 2 months), protein powders and vitamin D+calcium (first 3-6 months) and daily mineral-vitamin supplement (first 1-2 years) in the postoperative period. The recommended lifetime maintenance doses of these supplements were reminded to patients at each visit. During the follow-ups, additional doses of minerals and vitamins were given for specific deficiencies.

Statistics

The SPSS 22.0 (SPSS, Inc., Chicago, IL, USA) was used for statistical analysis. Mean ± Standard Deviation (Mean±SD) and descriptive analysis measures were used for the characteristics of the patients. The Chi-Square statistics were used for categorical data, the categorical variables (n) were compared with percentages, and an unpaired students t-test was used for continuous variables. The Kruskal Wallis and One-Way Analysis of Variance were used for further analysis between the groups. The statistical data were considered significant if $P < 0.05$.

RESULTS

The study was conducted on 1267 patients in total. 69.8% (n=885) of the patients were women. The mean age was found to be 48.5±11.6 years. The patients were followed up for 3.4±1.6 years postoperatively and were called for follow-ups every 6 months. The mean preoperative weight of the patients was 114.6±26.4 and the preoperative BMI was 44.5±2.8. In the follow-ups, the mean total weight loss was 45.6±4.8 kg, postoperative weight decreased to 73.2±6.4, and postoperative BMI to 24.6±1.2. Also, 32.5% of the patients were Class II and 67.4% were Class III obese; 52.6% of them formed the Ideal BPL group and 47.3% the standard BPL group. The mean Ideal BLP length was calculated as 210.6±8.1 cm. DM2 was the most common preoperative comorbidity. The results are shown in Table 1.

In the present study, when the Ideal BPL group and the standard BPL group were compared in terms of clinical complications in the OA-MGB procedure, diarrhea, constipation, malodorous stool, greasy stool, excessive weight loss, dumping, and protein malnutrition were found to be statistically significantly higher in the standard BPL group. Intraoperative small bowel injury was more common in the Ideal BPL group and was statistically significant. In the Ideal BPL group, 1 person died because of leakage. Other clinical manifestations and complications were similar in the groups. In the follow-ups, 11 patients with protein malnutrition and excessive weight loss were converted into the standard BPL group. Revision surgery was performed on 8 patients in the standard group because of insufficient weight loss and/or weight gain. The results are shown in Table 2.

The hemogram, serum iron, ferritin, serum albumin, serum vitamin B12, calcium, and phosphorus in the 3.4±1.6-year follow-up of the Ideal BPL group postoperative laboratory markers were statistically significantly higher than the standard BPL group in the OA-MGB procedure. The secondary elevation of parathormone was statistically and significantly higher in the standard BPL group. The groups were similar in terms of other laboratory biomarkers. The results are shown in Table 3.

According to postoperative laboratory data, the Ideal BPL group had statistically significantly lower serum iron, ferritin, hemoglobin A1C, ALT, triglyceride, and serum vitamin B12 levels than in the preoperative period. Although other biomarkers were low in the postoperative period, no statistical difference was detected. In the standard BPL group, hemogram, serum iron, ferritin, hemoglobin A1C, serum albumin, ALT, triglyceride, calcium, and phosphorus were low at statistically significant levels in postoperative laboratory data. Secondary elevation of parathormone was also significant. No statistically significant differences were found in other biomarkers. The findings are shown in Tables 4 and 5.

DISCUSSION

Less malabsorption, similar metabolic remission, weight loss, and fewer complications were observed in the Ideal BPL group, which was calculated by measuring the length of the small intestine in the present study. Postoperative Ideal BPL group clinical and laboratory biomarker data were closer to preoperative values. Nutritional deficiency and protein malnutrition were detected in the standard BPL group, but not in the Ideal BPL group. In this context, biliopancreatic limb length calculated over the length of the small intestine was found to be a more acceptable bypass length.

Acceptable weight loss was detected in One Anastomosis or Mini Gastric Bypass Procedure. A mean weight loss of 45.6±4.8 kg was detected in the whole group in the post-operative 3.4±1.6-year follow-up. It can be argued that there was similar weight loss in the groups. Also, early and late postoperative complications were higher in the standard BPL group. Intestinal injury was found to be more common in the Ideal BPL group in the follow-ups. One person died because of the leakage. The most common comorbidity accompanying obesity was DM2. These findings were found to be compatible with the literature data (12). The postoperative hemoglobin A1C value was significantly lower compared to the preoperative period in the groups. However, postoperative hemoglobin A1C values of the groups were similar. It can be argued that there was similar DM2 remission in the groups.

Different methods were used in the past to calculate the length of the bowel bypass in One Anastomosis or Mini Gastric Bypass Procedure. Standard lengths of 100-200 cm, 180-200 cm, or 250-300 cm for BPL were suggested in some previous studies (13-14). Bypass length was calculated according to the BMI values in some other studies (11). A significant amount of malabsorption and protein malnutrition were reported in previous studies. Severe protein malnutrition is the most important complication in approximately 1.0% of patients in this procedure and was reported to result in liver failure and death (15-16). These complications are associated with BPL length (17). Nutritional deficiencies and protein malnutrition were not observed in the Ideal BPL group in the present study. Greasy and malodorous stool, diarrhea, excessive weight loss, dumping, protein malnutrition, and constipation were the most common problems in the standard BPL group. Because of these findings, nutritional deficiency and malnutrition were significantly higher in the standard BPL group, similar to the literature data. Based on these findings, 1.8% (n=11) cases were converted from the AO-MGB procedure.

Serum biomarkers are an indicator of nutritional status, malabsorption, and synthesis functions of the liver and are related to adequate intake and absorption of micronutrients, proteins, and electrolytes (18). Previous studies showed that more malabsorption, malnutrition, micronutrient, electrolyte deficiency, and nutritional deficiencies are associated with longer BPL in OA-MGB (19-20). In the present study, the hemogram, serum iron, ferritin, serum albumin, serum vitamin B12, calcium, and phosphorus were obtained in the 3.4±1.6-year follow-up of the Ideal BPL group postoperative laboratory markers were significantly higher than the standard BPL group. Secondary elevation of parathormone was detected in the standard BPL group. Also, no statistical differences were detected in the postoperative period in the preoperative serum biomarkers hemogram, albumin, 25-OH vitamin D3, calcium, phosphorus, and parathormone levels in the Ideal BPL group. In this context, it was seen that the Ideal BPL group had better nutritional status and better absorption of micronutrients, proteins, and electrolytes when compared to the standard group.

The serum biomarkers such as hemogram, serum iron, ferritin, serum albumin, ALT, triglyceride, calcium, and phosphorus levels were significantly lower in the postoperative period in the standard BPL group and parathormone was significantly higher. Malnutrition and nutritional deficiency were found in this group. There appeared to be malabsorption of micronutrients and electrolytes. In the present study, adequate weight loss was not achieved in 1.3% of the patients in the standard group, and/or it was observed that they regained weight. It was seen in the study that there was no standard bowel length in patients. In this context, standard BPL remained long in some patients and short in others. The preoperative serum iron, ferritin, and serum vitamin B12 levels were statistically and significantly lower in the postoperative period in the Ideal BPL group. The stomach volume is reduced and malabsorption is created in this procedure. For this reason, some micronutrients, albumin, and electrolytes are expected to be deficient. This deficiency should not cause nutritional deficiencies and protein malnutrition.

CONCLUSION

As reported in the literature, nutritional deficiency and protein malnutrition in a fixed standard BPL of 180-200 cm must not be underestimated, which was demonstrated in the present study. The standard BPL remains short in some cases. As seen in the study, weight loss and metabolic remission were found to be similar to standard BPL length in Ideal BPL calculated over small bowel length. However, the nutritional deficiencies and protein malnutrition detected in the OA-MGB procedure were not observed in the Ideal BPL group. The Ideal BPL length appears to be safe and effective. The study showed that Ideal BPL length is superior to standard BPL with less micronutrient, and electrolyte deficiencies when providing similar weight loss and metabolic remission results.

Conflict of Interest

There is no conflict of interest between the authors.

Financial Disclosure

There is no financial disclosure

Authors Contributions

Plan, design: EA, ZE, HE, FG and KG; Material, methods and data collection: EA, FG and KG; Data analysis and comments: EA, ZE, HE, FG and KG; Writing and corrections: EA, ZE, HE, FG and KG.

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Table 1: The demographic and clinical characteristics of the patients

Parameters	**OA-MGB (n=1267)**
Age, years, mean ± SD	48.5±11.6
Female, sex (n, %)	885 (69.8%)
Follow-up duration, years, Mean±SD	3.4±1.6
Weight • Preoperative weight • Postoperative weight	 114.6±26.4 73.2±6.4
Total weight loss, kg (Mean ± SD) in follow-ups	45.6±4.8
BMI class, kg/m^2, *n* (%) • 35-39.9 class II, kg/m^2, *n* (%) • ≥40 class III, kg/m^2, *n* (%)	 412 (32.5%) 855 (67.4%)
BMI, kg/m^2, mean ± SD • Preoperative BMI • Postoperative BMI	 44.5±2.8 24.6±1.2

Co-morbidities • DM2, *n* (%) • OSA, n (%) • Other diseases (HT, HL, PCOS, fatty liver, ...), n (%)	 824 (65.0%) 54 (4.2%) 389 (30.7%)
BPL group, *n* (%) • Standard 180-200 cm, n (%) • BPL was calculated by measuring bowel length, n (%) --- [Ideal BPL]	 600 (47.3%) 667 (52.6%)
The group whose bowel length was calculated, cm, Mean±SD (n=667) • The shortest bowel length, cm • The longest bowel length, cm • The shortest BPL, cm • The longest BPL, cm • BPL, cm, Mean±SD	626.8±24.5 270 1190 90 390 210.6±8.1

Data are expressed as mean ± SD, median. BMI; Body mass index, DM2; Diabetes Mellitus Type 2, OSA; Obstructive Sleep Apnea, HT; Hypertension, HL; Hyperlipidemia, PCOS; Polycystic Ovarian Syndrome, BPL; Biliopancreatic Limb Length.

Table 2: The comparison of the Ideal BPL group and standard BPL group in terms of clinical findings and complications in the AO-MNG procedure

Parameters	**Ideal BPL, n=667 (52.6%)**	**Standard BPL, n=600 (47.3%)**	**P value**
Diarrhea, n (%)	9 (1.3%)	36 (6%)	0.001
Bile reflux, n (%)	12 (1.7%)	11 (1.8%)	0.576
Esophageal clinical reflux, n (%)	12 (1.7%)	13 (2.1%)	0.574
Anastomotic or marginal ulcer, n (%)	11 (1.6%)	12 (2%)	0.176
Vomiting, *n* (%)	6 (0.8%)	7 (1.1%)	0.752

Constipation, *n* (%)	2 (0.2%)	16 (2.6%)	0.034
Malodorous defecation, n (%)	104 (15.5%)	168 (28%)	0.048
Fatty defecation, n (%)	103 (15.4%)	182 (30%)	0.021
Leakage, n (%)	6 (0.8%)	5 (0.8%)	0.673
Excessive weight loss, n (%)	0	11 (1.8%)	0.032
Dumping, *n* (%)	6 (0.8%)	16 (2.6%)	0.047
Protein malnutrition, n (%)	0	14 (2.3%)	0.035
Liver failure, n (%)	0	8 (1.3%)	0.146
Bowel injury during surgery, n (%)	6 (0.8%)	0	0.032
Mortality, n (%)	1 (0.1%)	0	

Data are expressed as n (%).

Table 3: The comparison of postoperative laboratory markers of the Ideal BPL group and the standard BPL group in the AO-MNG procedure

Parameters	**Ideal BPL (Mean±SD)**		**Standard BPL (Mean±SD)**		**P value***
	Pre-op	**Post-op**	**Pre-op**	**Post-op**	
Hemoglobin, gr/dL	12.1±1.3	**11.9±1.2**	12.3	**10.9±1.4**	0.026
Serum iron, ng/mL	24.6±5.3	**18.2±3.7**	23.9±2.6	**10.1±1.8**	0.043
Ferritin, ng/mL	36.2±6.8	**18.4±5.8**	34.8±4.0	**4.6±1.6**	0.001
Hemoglobin A1C, %	8.6±2.1	**5.4±0.6**	9.2±0.5	**5.5±0.3**	0.683

Serum albumin, gr/dL	4.6±0.4	**4.2±0.6**	4.7±0.5	**3.5±0.4**	0.032
Alanine aminotransferase, U/L	46.8±12.6	**12.5±6.7**	43.9±13.3	**14.7±5.4**	0.759
Triglycerides, mg/dL	212.5±24.2	**78.9±11.2**	232.3±21.6	**83.6±13.1**	0.581
Low-density lipoprotein, mg/dL	134.8±13.6	**122.4±10.8**	128.2±16.7	**118.5±9.7**	0.625
Serum vitamin B12, pg/mL	258.4±92.4	**200.3±68.8**	264.9±89.6	**234.9±58.1**	0.048
25-OH D3 vitamin, ng/mL	16.1±5	**18.7±6.2**	19.2±3.9	**17.3±2.6**	0.463
Calcium, mg/dL	9.7±1.5	**9.1±0.5**	9.5±0.7	**8.1±1.1**	0.047
Phosphor, mg/dL	4.2±0.3	**3.6±0.4**	4.4±0.6	**2.6±0.3**	0.014
Parathormone, pg/mL	74.5±15.9	**80.2±16.5**	68.9±18.4	**112.3±21.7**	0.002

Data are expressed as mean ± SD, median, BPL; Biliopancreatic limb length. When the Ideal BLP group preoperative blood markers and standard BLP group preoperative blood markers were compared in all parameters, $p>0.05$. The comparison of the blood markers obtained in the Ideal BLP group postoperative 3.4±1.6 years' follow-up with the standard BLP group postoperative blood markers are given here.

Table 4: The comparison of Ideal BPL group preoperative and postoperative laboratory biomarkers in the AO-MNG procedure

Parameters	Preoperative Ideal BLP group	Postoperative Ideal BLP group	P-value
Hemoglobin, gr/dL	12.1±1.3	11.9±1.2	0.052
Serum iron, ng/mL	24.6±5.3	18.2±3.7	0.048
Ferritin, ng/mL	36.2±6.8	18.4±5.8	0.026
Hemoglobin A1C, %	8.6±2.1	5.4±0.6	0.001
Serum albumin, gr/dL	4.6±0.4	4.2±0.6	0.063
Alanine aminotransferase, U/L	46.8±12.6	12.5±6.7	0.001
Triglycerides, mg/dL	212.5±24.2	78.9±11.2	0.012
Low-density lipoprotein, mg/dL	134.8±13.6	122.4±10.8	0.583
Serum vitamin B12, pg/mL	258.4±92.4	200.3±68.8	0.049
25-OH D3 vitamin, ng/mL	16.1±5	18.7±6.2	0.341

Calcium, mg/dL	9.7±1.5	9.1±0.5	0.213
Phosphor, mg/dL	4.2±0.3	3.6±0.4	0.258
Parathormone, pg/mL	74.5±15.9	80.2±16.5	0.540

Data are expressed as mean ± SD, median, BPL=Biliopancreatic limb length

Table 5: The comparison of standard BPL preoperative and postoperative laboratory data in the AO-MNG procedure

Parameters	**Preoperative standard BPL group**	**Postoperative standard BLP group**	**P-value**
Hemoglobin, gr/dL	12.3	10.9±1.4	0.024
Serum iron, ng/mL	23.9±2.6	10.1±1.8	0.012
Ferritin, ng/mL	34.8±4.0	4.6±1.6	0.001
Hemoglobin A1C, %	9.2±0.5	5.5±0.3	0.001
Serum albumin, gr/dL	4.7±0.5	3.5±0.4	0.048
Alanine aminotransferase, U/L	43.9±13.3	14.7±5.4	0.016
Triglycerides, mg/dL	232.3±21.6	83.6±13.1	0.035
Low-density lipoprotein, mg/dL	128.2±16.7	118.5±9.7	0.536
Serum vitamin B12, pg/mL	264.9±89.6	234.9±58.1	0.145
25-OH D3 vitamin, ng/mL	19.2±3.9	17.3±2.6	0.349
Calcium, mg/dL	9.5±0.7	8.1±1.1	0.038
Phosphor, mg/dL	4.4±0.6	2.6±0.3	0.016
Parathormone, pg/mL	68.9±18.4	112.3±21.7	0.006

Data are expressed as mean ± SD, median, BPL=Biliopancreatic limb length

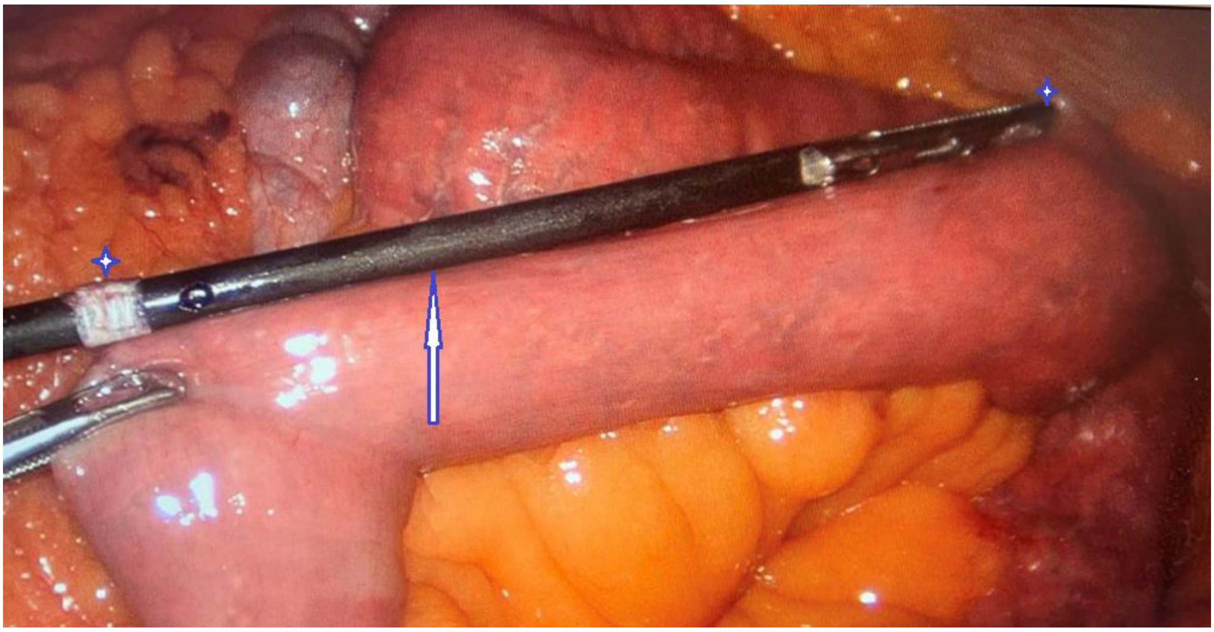

Image 1: The process of measuring the length of the small intestine to determine the length of the biliopancreatic limb and common duct; the small intestine length is measured firstly by finding the Treitz Ligament. The image shows the method of measuring a small bowel length of 10 cm.

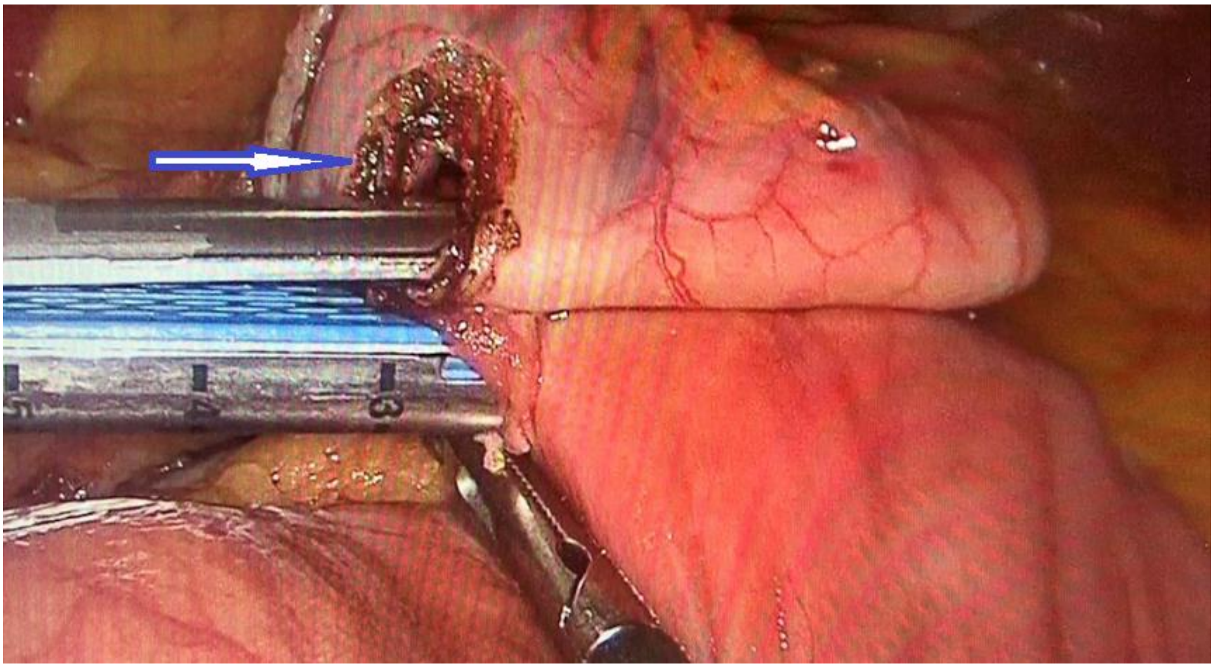

Image 2: The ~2.5 cm-long gastroenteric anastomosis line is seen between the biliopancreatic limb and the common canal.

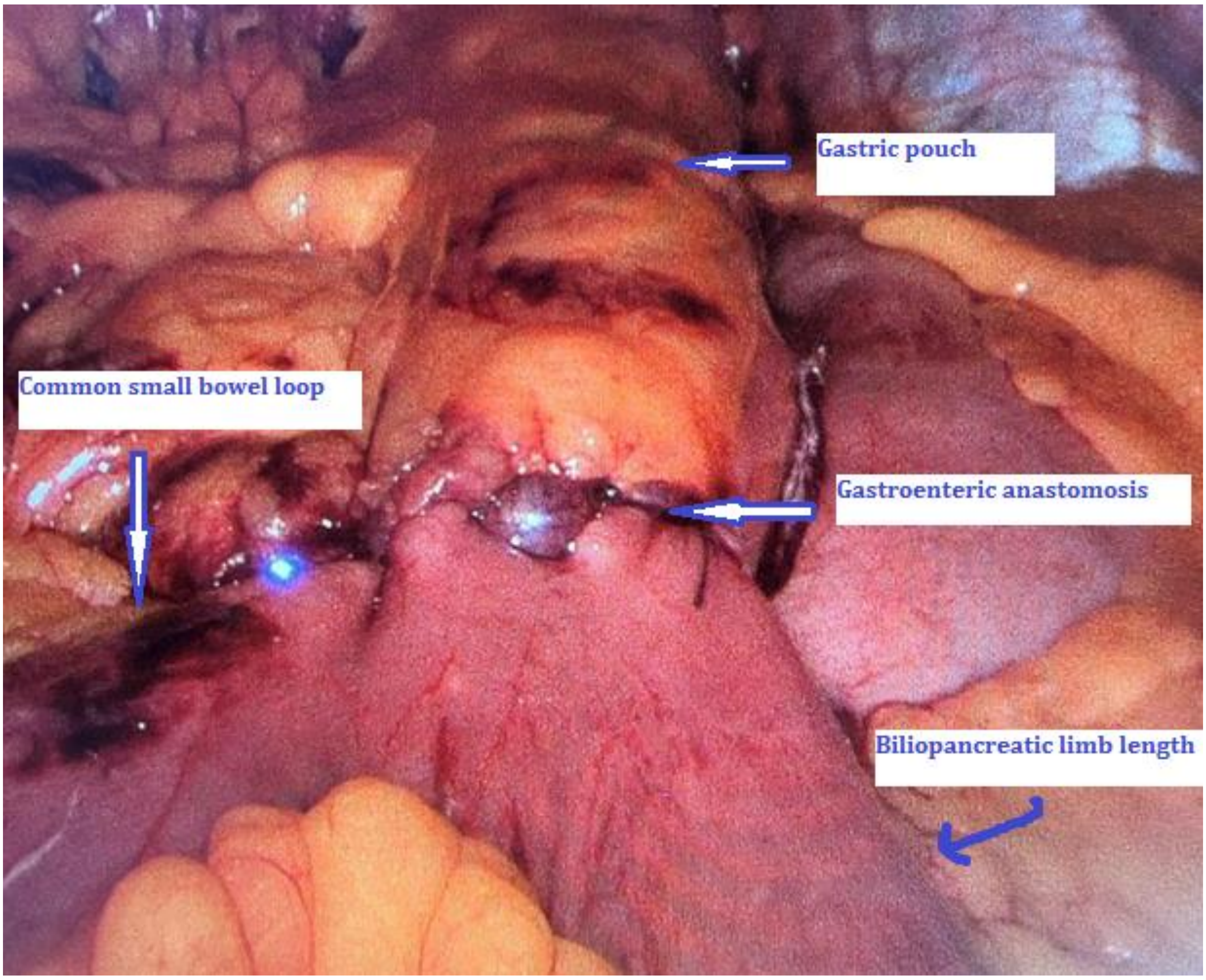

Image 3: The AO-MGB procedure, gastric pouch (~15 cm), gastroenteric anastomosis ~2.5 cm long, biliopancreatic limb length (1/3 length of the small intestine), and common small bowel loop (efferent limb) are given here.