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ORIGINAL CONTRIBUTION

Revision of Roux-en-Y Gastric Bypass with Limb Distalization for Inadequate Weight Loss or Weight Regain

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Abstract

Background Of patients undergoing Roux-en-Y gastric bypass (RYGB), 15–35% of patients fail to achieve "adequate" weight loss or regain significant weight. Multiple solutions have been proposed, but not well studied. We report our experience with limb distalization with lengthening the biliopancreatic (BP) limb and shortening the common channel (CC).

Methods We retrospectively reviewed data from patients undergoing laparoscopic limb distalization for excess weight loss (EWL) <50% or BMI >35 kg/m^2 after RYGB from 2012 to 2017. The BP limb was lengthened and CC was shortened to 100–200 cm. Perioperative outcomes such as morbidity, weight loss, nutritional deficiencies, comorbidity remission, and operative details were analyzed.

Results Twenty-two patients were included. The mean BMI prior to RYGB was 54.1 ± 8.5 kg/m^2 and 43.0 ± 5.5 kg/m^2 prior to limb distalization. The mean follow-up was 18.3 ± 12.9 months with a mean BMI change, %EWL, and %TWL (total weight loss) of 11.8 ± 7.4 kg/m^2, 62.3 ± 32.4%, and 25.4 ± 14.4%, respectively. The total mean BMI change, %EWL, and %TWL from RYGB was 22.2 ± 9.9 kg/m^2, 77.8 ± 23.6%, and 40.2 ± 13.3%, respectively. Of patients with persistent comorbidities, remission rates of diabetes, hypertension, and gastroesophageal reflux disease were 100%, 17%, and 38%, respectively. The mean operative time was 132.6 ± 54.4 min and mean hospital stay was 2.2 ± 1.3 days. Overall morbidity was 27.3%. Three patients (13.6%) developed nutritional deficiencies requiring reversal surgery.

Conclusion In patients with inadequate weight loss or weight regain after RYGB, limb distalization with lengthening of the BP limb is an effective procedure for additional weight loss and further improvement of comorbidities. Nutritional complications are a risk, but can be minimized with close follow-up and patient compliance.

Keywords Limb distalization · Shortened common channel · Long biliopancreatic limb · Revisional gastric bypass surgery

Introduction

There have been significant changes in weight loss surgery over the years, but Roux-en-Y gastric bypass (RYGB) currently remains the gold standard for weight loss and resolution of obesity-related comorbidities. The outcomes of the technique have been well studied and boasts promising results with a 60–80% mean excess weight loss (EWL), high rates of improvement of comorbidities, low complication rates, and reasonable long-term weight loss maintenance [1–4]; however, studies have shown that RYGB does not yield the same results for everyone. Fifteen to 35% of patients fail to achieve "adequate" weight loss or significantly regain weight after surgery, which is traditionally defined by EWL < 50% or a BMI > 35 kg/m^2 [4, 5]. This rate is even higher in superobese patients (BMI > 50 kg/m^2) at about 40% [6]. For these patients, multiple surgical and endoscopic techniques have been employed without consistent or meaningful success [7–13].

The RYGB was initially thought to assert its effects by a combined restrictive and malabsorptive mechanism; however, over the years, it has been demonstrated that the RYGB is mostly a restrictive operation [14–17]. The biliopancreatic

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diversion/duodenal switch (BPD/DS) is a known malabsorptive procedure and some groups have performed conversions from RYGB to BPD/DS, but it is technically challenging with increased perioperative morbidity [15, 18–21]; therefore, others have investigated the effects of adding a more malabsorptive aspect to the RYGB by shortening the common channel (CC) with lengthening either the Roux or biliopancreatic (BP) limb. The results have shown that both techniques provide increased weight loss at the expense of potential nutritional deficiencies, but lengthening the BP limb resulted in more weight loss with more nutritional issues [9]. Variable lengths of the resultant CC of 50–300 cm have been investigated with varying results with weight loss ranging from 48 to 85% EWL, protein malnutrition rates of 7–31%, and inconsistent reports of comorbidity resolution, leading to no consensus on the optimal length [9, 22–28]. Our group examined our experience with limb distalization (LD) by lengthening the BP limb and creating a CC length of 100–200 cm as a revisional procedure for inadequate weight loss/weight regain after RYGB to investigate its outcomes on additional weight loss and comorbidity remission. This report summarizes our early experience.

Methods

Approval was obtained from our institutional review board. A retrospective review of a prospectively maintained database was performed to identify patients who had undergone revision of their RYGB with a LD procedure from December 2012 to April 2017. These patients had been identified as candidates for the LD procedure due to weight regain/inadequate weight loss defined as EWL < 50% or BMI > 35 kg/m^2. Patient history, physical exam, blood work, and appropriate studies such as upper gastrointestinal studies, computed tomography, and/or esophagoduodenoscopy were performed to rule out any anatomic or metabolic causes of persistent morbid obesity. A multidisciplinary team including bariatric dieticians and psychologists were involved and patients demonstrating lack of reliable follow-up or compliance to nutritional recommendations were not offered the operation. The risk of nutritional deficiencies, increased bowel movements, and need for more expensive nutritional supplements were carefully discussed with the patients.

The Operation

All cases were performed laparoscopically. Adhesions were lysed as necessary, but the gastrojejunostomy was not manipulated. All limbs were identified, marked with different colored sutures in order to not confuse them (Reviewer #2), then measured several times by visual inspection using instrument lengths. The Roux limb was detached from the jejunojejunostomy by dividing it with a stapler, leaving a small stump, (Reviewer #2) and re-anastomosed closer to the terminal ileum (TI) in the usual fashion (Reviewer #2) creating a long, unmeasured (Reviewer #1) BP limb. At the beginning of our experience, the Roux limb was re-anastomosed at about 100–150 cm from the TI based on the experience of others (Reviewer #1), but this was changed to 200 cm after three patients required reversal for nutritional deficiencies. The mesenteric defect was selectively closed for large defects.

Nutritional Care

Postoperatively, patients were started on vitamin supplements using the American Society of Metabolic and Bariatric Surgery's (ASMBS) nutritional recommendations for BPD/DS as a guide (Table 1) [29]. Originally, a choice of supplementation was provided: Bariatric Advantage Multi EA or Celebrate Vitamins Multi-ADEK plus 60 mg of iron. An additional 1200–1500 mg of calcium was also advised. Our recommendations were adjusted throughout our experience and eventually Celebrate Vitamins Multi-ADEK plus iron was recommended. Also, calcium recommendations were increased to 1800–2400 mg and protein recommendations were increased from 60 to 70 g daily to 80 g daily. Patients were instructed to separate doses of the multivitamin to hopefully aid in absorption.

Follow-up

All patients were scheduled for follow-up postoperatively at 2 weeks, 6 weeks, every 3 months for 1 year, and then every 6 months. Blood work, including nutrition levels was recommended every 3 months. All patients were also contacted by phone to check in on their condition and overall satisfaction after surgery.

Statistics

Descriptive statistics were reported as means with standard deviations, ranges, and percentages. Statistical analysis was performed using t test for continuous data and Fisher's exact or χ^2 test for categorical data with $p < 0.05$ to determine statistical significance where applicable.

Results

Twenty-two patients underwent LD procedures from December 2012 to April 2017. There were 19 females (86%) and 3 males (14%) with a mean age of 45.9 ± 7.1 years. The mean follow-up time was 18.3 ± 12.9 months. During this time, the mean BMI change, %EWL, and %TWL (total

Table 1 Comparison of recommended nutritional supplements

	ASMBS DS guidelines	Bariatric Advantage advanced multi-EA	Celebrate multi-ADEK (+ iron)
Cost (per month)	–	$37.45	$24.95 + $12.95 (60 mg iron) = $37.90
Vitamin A (IU)	10,000	10,000	25,000
Vitamin D (IU)	3000	3000	3000
Vitamin E (IU)	400	150	300–400 (chewable/capsule are different)
Vitamin K (mcg)	300	300	650
Zn (mg)	16–22	15	45
Cu (mg)	2	2	4.5
Fe (mg)	45–60	45	60 (not in multivitamin)
Ca (mg)	1800–2400	0	0

weight loss) since LD was 11.8 ± 7.4 kg/m^2, 62.3 ± 32.4%, and 25.4 ± 14.4%, respectively (Table 2, Fig. 1). The total mean BMI change, %EWL, and %TWL from initial RYGB was 22.2 ± 9.9 kg/m^2, 77.8 ± 23.6%, and 40.2 ± 13.3%, respectively. Nineteen out of 21 patients (90.5%) (excluding the one mortality due to lack of data) achieved successful weight loss defined as EWL > 50% from original pre-RYGB weight.

Table 3 provides perioperative outcomes data. Mean operative time was 132.6 ± 54.4 min with a trend toward shorter operative times of less than 60 min with more experience. Operative time was affected by lysis of adhesions in some cases. The new CC after distalization ranged from 100 to 200 cm, mean of 155.5 cm. The CC had been adjusted to 200 cm after three patients developed protein malnutrition. The total alimentary limb (Roux limb plus common channel) lengths ranged from 200 to 300 cm with a mean of 255.8 cm (Reviewer #1).

Overall postoperative morbidity rate was 27.3%, which included readmissions, reoperations, reversal surgery, and death. There were no anastomotic leaks or bleeding complications. The readmission rate was 13.6% and were due to dehydration, atrial fibrillation, and two bowel obstructions. Two patients underwent reoperation (9.1%) shortly after LD surgery for adhesive bowel obstruction. One patient had a laparoscopic lysis of adhesions and the other had an open resection of the jejunal-ileal anastomosis due to dense adhesions causing an obstruction and creation of new anastomoses, maintaining LD anatomy. There was one mortality (4.6%), which occurred 6 months postoperatively and was not related to the LD surgery.

Five patients (29.4%) had low albumin levels, but two had mildly low values and only three patients (13.6%) developed severe protein malnutrition and vitamin deficiencies requiring reversal to previous RYGB anatomy. Two of these patients were managed on Total Parenteral Nutrition (TPN) prior to reversal. All three patients were found to be noncompliant with nutritional supplementation and one patient also had failure of weight loss. The mean time from LD to reversal was 13.8 ± 4.0 months. Patients who were reversed had a significantly higher initial weight prior to RYGB (361.7 lb vs 325.2 lb, $p = 0.01$). They were also found to have significantly lower levels of copper, magnesium, ceruloplasmin, albumin, hemoglobin, and vitamins A, B1, E, and K ($p < 0.05$)

Table 2 Weight outcomes

	Before RNYGB	Before Distalization	6 months (from distalization)	12 year (from distalization)	24 months (from distalization)	Mean follow-up of 18.3 months
	$n = 22$	$n = 22$	$n = 20$	$n = 19$	$n = 6$	$n = 18$[a]
Weight (lbs)	333.6 (± 50.1)	267.5 (± 35.7)	227 (± 39.9)	211.2 (± 38.4)	206.17 (± 31)	191.58 (± 38.2)
Weight change (lbs) [total from original]	-- [--]	-- [66.0 (± 44.1)]	41.1 (± 20) [101.5 (± 48.1)]	58.4 (26.3) [118.7 (± 54.4)]	67.3 (± 36.6) [148.3 (± 53.3)]	71.6 (± 41.3) [133.6 (± 55.0)]
BMI (kg/m^2)	54.1 (± 8.5)	43.0 (± 5.5)	33 (± 12.3)	34.5 (6.5)	34.13 (± 2.7)	31 (± 5.5)
BMI change (kg/m^2) [total from original]	-- [--]	-- [11.0 (± 7.5)]	6.6 (± 3.3) [16.7 (± 7.6)]	9.2 (± 4.5) [19.8 (± 9.1)]	11.57 (± 7.0) [26.1 (± 8.7)]	11.8 (± 7.4) [22.2 (± 9.9)]
%EWL [total from original]	-- [--]	-- [35.0% (± 19.6)]	40.2% (± 20.7) [58.5% (± 20.5)]	55.5% (± 29.4) [67.0% (± 20.7)]	51.85% (± 21.6) [71.1% (± 12.5)]	62.3% (± 32.4) [77.8% (± 23.6)]
%TWL [total from original]	-- [--]	-- [18.9% (± 11.2)]	15.5% (± 7.1) [30.2% (± 11.7)]	21.9% (± 9.5) [35.1% (± 12.3)]	24.1% (± 12.2) [40.9% (± 11.3)]	25.4% (± 14.4) [40.2% (± 13.3)]

RYGB Roux-en-Y gastric bypass, *BMI* Body Mass Index, *EWL* excess weight loss, *TWL* total weight loss

[a] Excludes reversals and death

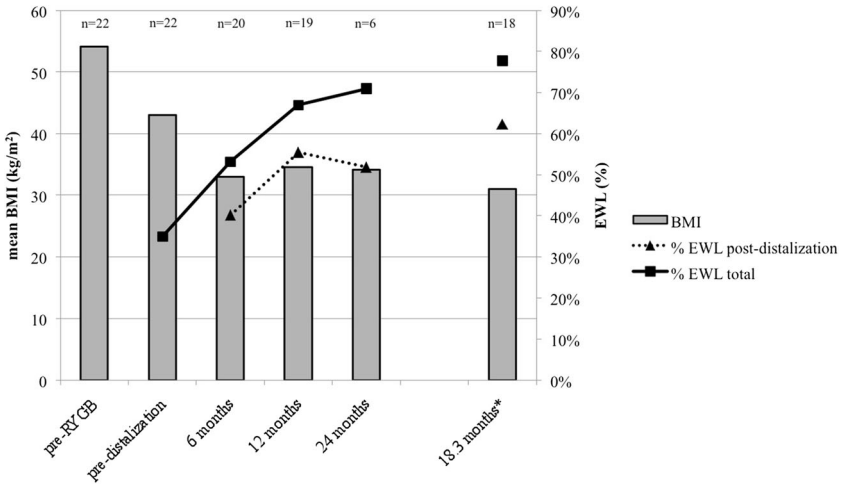

Fig. 1 Progression of weight loss. *mean follow up. RYGB = Roux-en-Y gastric bypass; BMI = Body Mass Index; EWL = excess weight loss

postoperatively than those who did not require reversal. All patients had a resolution of their nutritional deficiencies after reversal.

Perioperative characteristics of patients with abnormal nutritional factors were compared with those without and there were no significant differences between the groups except: patients with low Vitamin A had significantly shorter mean CC lengths (140 cm vs 175 cm, $p = 0.03$); patients with low ceruloplasmin had a higher initial starting weight prior to RYGB (361.7 lb vs 316.9 lb, $p < 0.01$); and patients with high parathyroid hormone had higher pre-distalization weights and BMI (281.7 lb vs 241.3 lb, $p < 0.02$ and 45.5 kg/m^2 vs 40.1 kg/m^2, $p < 0.05$, respectively). When comparing patients with low albumin to normal, there were no statistically significant differences between the groups. Table 4 shows additional nutritional results.

Table 3 Limb distalization perioperative results

	Mean (SD)	Range
Operative time (min)	132.6 (± 54.4)	53–257
Roux limb length (cm) before distalization	107.4 (± 34.8)	50–180
BP limb length (cm) before distalization	45 (± 28.2)	20–150
New common channel (cm) after distalization	155.5 (± 33)	100–200
EBL (ml)	23 (± 38.6)	0–100
Length of hospital stay (days)	2.2 (± 1.3)	1–7
Follow-up (months)[a]	18.3 (± 12.9)	0–52.5
BMs/day[a]	3.5 (± 1.2)	1–6
Readmissions	13.6%	–
Reoperations (excluding reversals)	9.1%	–
Reversals of limb distalization	13.6%	–
Morbidity	27.3%	–
Mortality	4.6%[b]	

BP biliopancreatic, *EBL* estimated blood loss, *BM* bowel movement

[a] Reversals and death excluded

[b] Unrelated to limb distalization surgery

Sixty-eight percent of patients had a persistent comorbidity prior to LD in the form of hypertension, diabetes, gastroesophageal disease, or obstructive sleep apnea (OSA) defined by the need for active treatment or diagnosis by relevant testing (i.e., sleep study). Table 5 demonstrates the pre- and post-distalization rates. Remission was defined by the cessation of medications or HbA1c level < 6.0% (for diabetes). Unfortunately, not all patients had available HbA1c data. Of the 4 patients with diabetes, 3 (75%) did not require any medications after LD and 1 patient who had not been on medication preoperatively had a decrease of HbA1c from 7.4 to 4.9%. Of the 6 patients with hypertension, 1 (17%) did not require any medications after LD and 1 had a reduction in medications, resulting in a 33.3% improvement rate. The remission of OSA could not be determined due to lack of follow-up and inconsistent use of CPAP (continuous positive airway pressure) therapy among these patients.

Fifteen of the 22 patients (68.2%) were successfully contacted by phone and 73.3% stated they were happy with their surgery. Of the 4 not satisfied, 2 patients had undergone reversal. One patient had lost insurance and could not afford the vitamins or maintain follow-up. The last unsatisfied patient desired additional results and had initiated medical weight loss.

Discussion

Inadequate weight loss or weight re-gain after RYGB is a complex matter that ultimately leaves the patient with the continued risks associated with morbid obesity. The lack of successful weight loss can be attributed to multiple different factors such as anatomic, metabolic, medical, and behavioral issues; however, once the correctable problems are excluded, some patients will still have a failure of the RYGB due in part to our continued lack of complete understanding of the mechanisms of action of the currently offered weight loss operations.

Table 4 Postoperative nutritional data

	n	Mean (SD)	Range	Reference range	% low or high
Nutrition labs follow-up (months)	19	20.8 (± 14.6)	0–58.4	–	–
Albumin	17	3.6 (± 0.64)	2.3–4.6	(3.5–5.2)	29.4% low
Hemoglobin	18	11.9 (± 1.3)	9.5–14	(11.5–16.4)	38.9% low
Hematocrit	18	36.7 (± 3.8)	30.5–43.4	(36–48)	38.9% low
Iron	17	66.4 (± 24)	36–123	(37–158)	5.9% low
Ferritin	18	131.6 (± 106)	16–333	(10–170)	31.3% high
Folate	19	18.2 (± 4.1)	9.1–24	(5.3–99)	0% low
Vitamin A	18	33.1 (± 22.8)	2.1–72.5	(32.5–78)	44.4% low
Vitamin B1	17	152.5 (± 44.3)	74–211	(70–180)	11.8% low
Vitamin B12	18	859.8 (± 589)	172–2000	(400–900)[b]	22.2% low
Vitamin D	18	25.3 (± 15)	7–72	(30–80)[c]	72.2% low
Vitamin E	16	6.8 (± 2.3)	2.1–11.9	(5.5–17)	25.0% low
Vitamin K	18	0.1 (± 0.1)	0.03–0.47	(0.10–2.20)	66.7% low
Ceruloplasm	16	23.7 (± 10.4)	9–50	(20–60)	18.8% low
Copper	16	0.97 (± 0.5)	0.46–2.13	(0.75–1.45)	31.3% low
Magnesium	17	1.98 (± 0.2)	1.6–2.2	(1.7–2.6)	5.9% low
Parathyroid Hormone	18	70.5[a] (± 38.2)	29–154	(15–65)	50% high
Zinc	17	0.57[a] (± 0.2)	0.16–0.79	(0.66–1.10)	82.4% low

[a] Out of reference range

[b] Our Weight Loss Surgery Center considers a Vitamin B12 level less than 400 as low for bariatric patients although our institutional range is 250–900

[c] Our Weight Loss Surgery Center considers a Vitamin D level less than 30 as low for bariatric patients although our institutional range is 20–80

Our group has pursued LD with a lengthened BP limb and a CC length of about 150–200 cm as a revisional surgery in this patient population. Review of our experience showed that with a mean follow-up of 18.3 months, patients had a mean EWL of 62.3% from the LD procedure (BMI decrease: 11.6 kg/m^2) and 77.8% from their original weight (BMI decrease: 22.2 kg/m^2). These results are comparable, if not greater than other studies showing an EWL ranging from 48 to 85% at 1–10 year follow-ups [5, 22–25, 27, 28, 30, 31].

The weight loss seen in LD is likely due to the greater degree of malabsorption that is added to the RYGB. Although the RYGB was once thought to have a restrictive and malabsorptive mechanism, several studies have shown that there is little malabsorption [14–17]. Therefore, a malabsorptive addition would likely produce greater results as seen with the BPD/DS, which offers a greater mean EWL and increased rate of comorbidity resolution than RYGB [32]; however, BPD/DS has a higher complication rate and greater technical complexity [18, 19, 32]. Keshishian et al. performed 47 conversions of vertical banded gastroplasties and RYGB to BPD/DS for insufficient weight loss [15]. They demonstrated an EWL of 69% and BMI decrease of 19.7 kg/m^2; however, the mean operative time was 3.5 h and leak rate was 15% in patients converted from RYGB. Others have shown lower leak rates, but stricture rates at the gastrogastrostomy of 33% [19]. Limb distalization adds a malabsorptive component to the RYGB, but avoids a high-risk gastric anastomosis, making it a technically less complex and less morbid procedure.

Limb distalization to provide malabsorption is complicated by the degree of malabsorption it may cause. In this regard, the length of the CC is critical; however, an optimal length has not been identified. Sugerman et al. reported their early experience using 50 cm for the CC [25]. All five of these patients developed severe protein malnutrition and two died from liver failure causing the group to switch to 150 cm. Other investigators performing LD have created CC lengths varying from 50 to 300 cm. The weight loss outcomes and rates of protein malnutrition have differed drastically with no optimal length established [5, 22–25, 27, 28, 30, 31, 33].

Table 5 Comorbidity outcomes

	Pre-distalization	Post-distalization remission
Hypertension	6/22 (27%)	1/6 (17%)
Diabetes	4/22 (18%)	4/4 (100%)
GERD	8/22 (36%)	3/8 (38%)
Obstructive sleep apnea	5/22 (23%)	NA

GERD gastroesophageal reflux disease; *NA* not available

In addition to establishing the optimal CC length, the effect of the two other limbs requires examination. Currently there is no consensus on the standard lengths of the Roux and BP limbs for either primary or revisional gastric bypass [17, 34–37]. Stefanidis et al. performed a systematic review of differing limb lengths in primary gastric bypass and concluded that although longer Roux limbs may be associated with a small degree of greater weight loss in the superobese, the length of the CC likely plays a greater role [6]. This has been supported by investigations of varying CC lengths for primary and revisional gastric bypass with adjustments of Roux and BP limb lengths [5, 16, 22–28, 30, 31, 33]. On the other hand, a recent randomized controlled trial by Homan et al. compared the effect of a longer BP limb (BP limb 150 cm, alimentary limb 75 cm) for primary RYGB to standard limb lengths (BP limb 75 cm, alimentary limb 150 cm) and demonstrated that a longer BP limb resulted in a significantly greater EWL that was maintained at 4 years [38].

In the case of revisional RYGB with LD, studies have also suggested that lengthening one limb over another may have different effects [9]. Tran et al. reviewed the results of groups lengthening different limbs and found that longer BP limbs provided greater weight loss, but also greater nutritional deficiencies [9]; however, there are no studies directly comparing the outcomes of lengthening the Roux limb versus BP limbs in LD due to small sample sizes and therefore a definitive conclusion cannot be made.

Nutritional deficiencies are a major concern of LD. Studies have shown that of patients undergoing LD with a lengthened BP limb, 8–31% develop protein calorie malnutrition, 4–21% require TPN, and 5–14% require reversal or lengthening of the CC [9]. The variability in the incidence of these nutritional complications may be due to varying bowel lengths among patients, differences in the method of measuring bowel lengths, lack of patient compliance, or incomplete understanding of nutritional supplementation [16, 39, 40]. Currently, there are no guidelines for supplementation after LD; however, with the aid of the ASMBS guidelines for BPD/DS and our experiences, we made adjustments to our recommendations with observed improvements [29]. We did have three patients who had trouble with compliance to supplementation and follow-up, eventually requiring reversal; however, most patients did not have significant nutritional complications. To prevent significant morbidity from malabsorption, patients require aggressive nutritional education and close follow-up. The increased supplementation requirements can also be expensive; therefore, any patient who is unable to be diligent with close monitoring or afford the supplements is at significant risk of nutritional morbidities and should not be offered the surgery.

The limitations of our study were mainly attributable to the study design. It was a retrospective examination and there were unavoidable biases and confounding factors related to the nature of the review. Due to the scarcity of patients meeting the criteria for the operation, we had a small sample size. Follow-up was limited to a mean of 18.3 months with our longest follow-up time being 53.3 months. Although there was some loss to follow-up after 1 year, the follow-up time was mostly limited due to our early experience. Our results demonstrate that LD provides greater weight loss and durability than other procedures such as pouch re-sizing/banding and endoscopic gastric outlet reduction and also has a lower perioperative morbidity profile and better technical ease than conversion to BPD/DS; however, we did not directly compare LD to other procedures and therefore, additional comparative studies with larger sample size and longer follow-up is required to determine superiority.

Conclusion

Our study provides additional data to others investigating options for patients with inadequate weight loss/weight regain after RYGB. More specifically, we examined the impact of lengthening the BP limb with a CC measuring 100–200 cm. We found that LD provides substantial additional weight loss, reasonable maintenance of weight loss, additional remission of comorbidities, and overall good patient satisfaction. There are some nutritional morbidities; however, with close follow-up and education, most patients do not require invasive intervention. We found that a CC length of 200 cm may be favorable in achieving the desired weight loss with a balance of decreased nutritional complications. Based on our results and others, we believe that revision of RYGB with LD by lengthening the BP limb for weight regain/inadequate weight loss is an effective procedure for motivated patients with reliable follow-up and compliance; however, this technique is relatively novel and additional studies need to be performed to determine its durability for weight loss, metabolic effect of long-term malabsorption, ideal CC length, and optimal nutritional support.

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Compliance with Ethical Standards

Conflict of Interest Author 6 is an editor of Obesity Surgery.

Ethical Approval All procedures performed in studies involving human participants were in accordance with the ethical standards of the institutional and/or national research committee and with the 1964 Helsinki declaration and its later amendments or comparable ethical standards.

Informed Consent For this type of study, formal consent is not required.

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