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CLINICAL RESEARCH

Is Weight Loss Better Sustained with Long-Limb Gastric Bypass in the Super-Obese?

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Abstract
Background While some studies have shown that long-limb gastric bypass with Roux limb length of 150 to 200 cm can attain better weight loss outcomes in super-obese patients (BMI >50 kg/m^2) than the standard limb gastric bypass with Roux limb length of 100 to 150 cm, other studies have not shown similar findings. Additionally, no study has demonstrated the optimal length of the Roux limb that will result in ideal weight loss. The purpose of this study is to compare the long-term weight loss and weight regain of standard limb length (SLL) and long limb length (LLL) gastric bypass in patients with BMI >50 kg/m^2.
Methods A total of 120 patients with BMI >50 kg/m^2 underwent either SLL (total bypass length=200, biliopancreatic limb=50–80 cm, Roux limb=120–150 cm) or LLL (total bypass length = 250 biliopancreatic limb=50–80 cm, Roux limb=170–200 cm) RYGB. The excess weight loss (EWL), the weight regain, and the rate of complications were measured at 1-, 2-, and 3-year follow-up. Statistical comparisons were performed using *t*-test.
Results There was no difference in patient demographics, pre-operative BMI, or comorbidities between the two groups: SLL (n=55) and LLL (n=65). In comparing standard- to long-limb cohorts, preoperative BMI was 56.1 ±5.34 vs. 57.5±6.05 kg/m^2, respectively. There was no statistical difference in percent EWL at 1, 2, and 3 years between the two groups [55.2 vs. 55 (P=0.933), 61.5 vs. 60.8 (P=0.831), and 61.1 vs.60 (P=0.932)]. There was no difference in percent weight regain between the two groups, 11.2 (SLL) and 5.2 (LLL) (P=0.13). The rates of complications were similar in the two groups.
Conclusion There is no difference in weight loss or weight regain between the SLL and LLL RYGB. Longer-limb gastric bypass is not required in patients with BMI >50 kg/m^2 for them to obtain long-term, sustained weight loss.

Keywords Gastric bypass · Roux limb · Excess weight loss · Weight regain

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Introduction

The current number of overweight and obese individuals worldwide is estimated to be approximately 1.7 billion [1]. In 1991, the National Institutes of Health considered surgery as one of the methods for achieving and maintaining long-term weight loss and effectively addressing the serious comorbidities associated with obesity; however, it was recommended that all patients should first be considered for treatment in a nonsurgical program before considering the surgical option [2]. Since 1960, surgeons have tried a variety of surgical procedures to treat obesity, starting with the jejunoileal bypass [3]. Currently, gastric bypass is the most common operation performed in the USA for morbid obesity [4]. While the exact mechanism of weight reduction after RYGB is still not fully understood, it has been suggested that restriction of intake due to a small gastric pouch and the malabsorption after bypassing most of the stomach, the duodenum, and part of the jejunum could explain the weight reduction outcome. [5].The literature demonstrates a significant weight loss in most patients after gastric bypass, with a concomitant improvement in the quality of life associated with an extended life

span due to improved or resolved obesity-associated comorbidities [6]. Most patients maintain >50% reduction in excess body weight for as long as 10 years after surgery [7]. Of note is the finding that gastric bypass fails in up to 10% of the patients (excess weight loss under 50%) [8].

A number of reports suggest that an increase in the length of the Roux limb in super-obese patients (SO) (BMI >50 kg/m^2) is associated with a significantly greater weight loss [9]. Whereas the noted improvement in weight loss outcome is seen early and late in the super-obese patients, it has not been observed in the morbidly obese patients (MO) (BMI <50 kg/m^2) [5, 10, 11]. In contrast, other studies have not reported differences in weight loss outcome on a longer follow-up in either SO or MO patients [12–14].

Although weight regain after gastric bypass has been previously described, very few surgical reports have looked at weight regain in relation to limb length with a long follow-up [12]. With these conflicting data, the question on whether the length of Roux limb affects the weight loss outcomes in SO patients remains unanswered. The purpose of this study is to compare the long-term weight loss and weight regain between the standard limb length (SLL) and long limb length (LLL) gastric bypass in patients with BMI >50 kg/m^2.

Methods

After IRB approval and in compliance with HIPAA regulations, the medical records of SO patients who underwent RYGB between 2002 and 2008 were reviewed, with attention to age, sex, ethnicity, comorbidities (diabetes mellitus, hyperlipidemia, hypertension obstructive sleep apnea, degenerative joint disease, asthma, and psychiatric disorders), complications, surgical technique, initial BMI, percent excess weight loss, and weight regain. Comparisons were made between two cohorts comprising the standard limb length group SLL (total bypass length of 200, biliopancreatic limb= 50–80 cm, Roux limb=120–150 cm) and the long limb length group LLL (total bypass length of 250, biliopancreatic limb= 50–80 cm, Roux limb=170–200 cm).

The follow-up period was 3 years and the outcomes were compared at 1, 2, and 3 years. All of the patients included in this study underwent gastric bypass. All gastric bypasses were done by the same attending surgeon; the same designated anesthesia team followed the same anesthesia protocol throughout the period of the study. Preoperative, perioperative, and postoperative data were collected retrospectively. All of the patients underwent preoperative history and physical examination by the attending surgeon. The investigations included right upper quadrant ultrasound, upper gastrointestinal endoscopy, and laboratory evaluation. Psychological and comprehensive medical evaluations, in addition to multiple educational sessions with a dietician, were also completed in all patients. The bypass lengths were the decision of the same attending surgeon. All SO patients who were operated prior to 2006 were offered a long-limb gastric bypass. For those who were operated in the period after 2006, following some surgical reports published at that time [11, 12], we did not perform long-limb bypasses and the total bypass length was limited to 200 cm, with a Roux limb limited to 150 cm.

At 50–80 cm from the ligament of Treitz, the jejunum was transected using the 60×2.5-mm GIA; Roux limb ranged between 120 and 150 cm in the SLL and 170 and 200 cm in the LLL. Our goal was to achieve a total bypass length of 200 in the SLL and 250 in LLL when adding the biliopancreatic limb and Roux limb lengths together. All measurements were done by the attending surgeon. Atraumatic bowel clamp was used for our measurements. The distance between the two ends of the bowel clamp when it was fully opened was 2.5 cm. Two openings were used to measure 5 cm and the bowel was run in 5-cm segments under full stretch using visual inspection. Jejunojejunostomy and a standard 20–30 cc gastric pouch were created using the GIA over a 34 French gastric tube. EEA was used to create an ante-colic, ante-gastric gastrojejunostomy. This anastamosis was reinforced with a running absorbable suture. The patients were started on clear liquids on the first postoperative day. The diet was advanced as tolerated and the patients were discharged home when deemed stable by the attending surgeon. The patients were followed up in our specialized bariatric surgery clinic. The percent EWL was compared at the end of each year of follow-up. Weight regain was evaluated at the end of the third year by comparing the percent EWL at that point with the highest percent EWL during the study period: weight regain = percent EWL (third year) − maximum percent EWL in the first and second year.

Data Analysis

Short and long afferent limb subgroups were compared using chi-square test for categorical variables and Student *t*-test for continuous variables. Continuous data are presented as mean ± standard deviation. *P* values less than 0.05 were considered significant. All statistical analyses were performed using SPSS 15.0 (Chicago, IL, USA)

Results

A total of 120 of the 141 super-obese patients who underwent gastric bypass between 2002 and 2008 at our bariatric surgery center were followed up for 1 year. Among these, 105 patients completed 2 years of follow-up (88%) and 78 patients completed 3 years of follow-up (65%). The low number in

the 3 years' follow-up group is in part due to loss of follow-up and in other part is due to the fact that a considerable number of super-obese patients were operated in 2007 and did not meet the criteria for 3 years' follow-up by the time this manuscript was written. The patients' demographics and comorbidities are shown in Table 1. There were 116 patients who underwent laparoscopic gastric bypass and four patients were converted to open, one in the SLL, and three in the LLL, but there was no statistically significant difference between the two groups. The two patients who had a total bypass length of 210 and 220 cm, respectively, were considered in the SLL group. One patient had a total bypass length of 230 and was included in the LLL group. There were no significant differences in age, sex, race, and comorbidities between the two groups. Weight loss outcomes presented as BMI and percent EWL are shown in Table 2. There were no significant differences in pre-operative BMI, post-operative BMI, and percent EWL at 1, 2, and 3 years of follow-up (Fig. 1). Weight regain occurred in 56% of the SLL and 61% of the LLL. Again there was no statistically significant difference observed between the two groups when the regained weight was compared, as shown in Table 2. Similarly, there was no difference in complication rate between the two groups; however, both incisional hernia and cholelithiasis approached statistical significance (Table 3).

Discussion

Obesity has been identified as the second most common cause of death from a modifiable behavior in the USA. In 2000, it was responsible for more than 400,000 deaths [15]. The surge in the number of gastric bypass surgery performed in the past decade has led to an advent of multiple technical variations of the procedure. One of these important variations was the length of the Roux limb. Various lengths have been reported in many centers, but no consensus exists about how long the Roux limb and the afferent limb should be for optimal weight reduction while avoiding nutritional and clinical complications. While the use of longer limb length in the morbidly obese and super-obese has been studied and reported from many surgical centers, the definition of short limb and long limb varies from center to center in many of these reports. For example, in some reports, the length of short-limb bypass was 50 cm (10-cm afferent limb and 40-cm Roux limb) and the length of the long-limb bypass was 200 (100-cm afferent limb and 100-cm Roux limb) [12, 16]. These lengths are different from the lengths described in this study, and the same kind of difference is noticed between multiple surgical reports (Table 4). Ciovica et al. retrospectively analyzed weight loss outcomes in 137 super-obese patients who underwent GBP, with a Roux limb length of 100 or 150 cm. Their result showed that patients with the 150-cm Roux limb lost more weight. Their patients' follow-up was limited to 1 year only [5]. On the other hand, Lee et al. described a linear relationship between the reduction in BMI and the Roux limb length.

They used a 100-cm Roux limb in patients with BMIs less than or equal to 40, and for every unit of BMI over 40 5 cm was added to the Roux limb length with a maximum length of 150 cm. In the 97 patients who completed the 1-year follow up, there was a greater absolute weight loss associated with an increase in Roux limb length [17].

Table 1 Demographic and clinical characteristics

Demographic and clinical characteristics		Total bypass length SLL 200	Total bypass length LLL 250	*P* value
Race	Hispanic	56	42	0.2
	AA	8	11	
	Asian	0	2	
	Caucasian	1	0	
Age	≤35	32	24	0.672
	>35	33	31	
Sex	Male	6	9	0.242
	Female	59	46	
Comorbidities	HTN	18	22	0.138
	DM	14	13	0.791
	Osteoarthritis	12	7	0.388
	Obstructive sleep apnea	8	8	0.724
	Hyperlipidemia	8	11	0.254
	Asthma	13	9	0.604
	Psychiatric disorder	10	6	0.469
Technique	Open	1	3	0.235
	Laparoscopic	64	52	

Table 2 Weight loss outcomes

BMI/EWL	Group	*N*, number of patients	Mean	Std. deviation	Std. error mean	*P*		
Pre-operative BMI	SLL200	65	56.1	5.34	0.7	0.152		
	LLL250	55	57.5	6.05	0.8			
BMI 1	SLL200	65	36.2	6.3	0.8	0.189		
First year	LLL250	55	37.8	7.7	1			
BMI 2	SLL200	52	34.4	5.8	0.8	0.364		
Second year	LLL250	53	35.7	8.1	1.1			
BMI 3	SLL200	32	34.4	5	0.9	0.182		
Third year	LLL250	46	36.7	8.5	1.3			
EWL 1	SLL200	65	55.2	14.5	1.8	0.933		
First year	LLL250	55	55	15.5	2.07			
EWL 2	SLL200	52	61.5	13.4	2.04	0.831		
Second year	LLL250	53	60.8	17.2	2.4			
EWL 3	SLL200	32	60.1	17.2	3.5	0.932		
Third year	LLL250	46	60	18.9	2.9			
Weight regain	Group	*N*	*N**	%	Weight regain (mean)	SD	SEM	*P*
Third year	SLL200	32	18	56	11.7	12.5	3.6	0.13
	LLL250	46	28	61	5.8	2.9	0.5	

N total number of patients, *N** total number of patients who regained weight in the third year of follow-up, *Weight regain* EWL3−Max (EWL1 or EWL2)

Pinheiro studied the effect of longer intestinal limbs to control the comorbidities in super-obese patients with 4 years of follow-up. He randomly divided a total of 105 patients with a body mass index of ≥50 kg/m^2 into a group with biliary limb and Roux limb lengths of 50 and 150 cm, respectively, and a group with biliary limb and Roux limb lengths of 100 and 250 cm, respectively. Both groups were followed up for 4 years. The patients with Roux limb of 250 cm had better control of both diabetes and lipid disorders. The excess weight loss was faster in this group but was similar in both groups at 4 years of follow-up [6]. The long limb length in their experience was 100 cm longer than the length described in our series. Interestingly, their findings were close to ours on the long-term follow-up.

Christou et al. looked at their experience in 228 patients with 10 years of follow up; 100 patients were super-obese. They compared the weight loss outcomes between the short-limb gastric bypass (10-cm afferent limb and 40-cm Roux limb) and the long-limb gastric bypass (100-cm afferent limb and 100-cm Roux limb). The long-limb bypass was observed to have a modest but not statistically significant improvement at 5 years in the super-obese patients. The difference was no longer seen at 10 years. They also reported a significant weight regain in patients from both groups; however, no comparison was made between the two groups [12]. In our experience, both groups showed evidence of weight regain, but the difference between the two groups was not statistically significant.

In a prospective randomized clinical trial, Inabnet et al. randomized 48 patients with BMI <50 to a short limb (biliopancreatic limb=50 cm, alimentary limb=100 cm) and long limb (biliopancreatic limb=100 cm, alimentary limb=150 cm) gastric bypass. Increasing the length of the

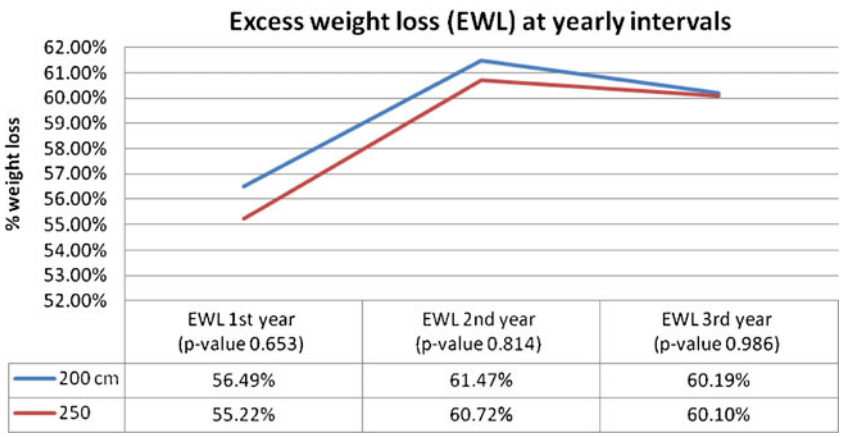

Fig. 1 EWL outcomes at follow-up: 1, 2, and 3 years

Table 3 Complications

Complications	200	250	*P*
Wound infection	9	3	0.126
Internal hernia	8	10	0.373
Incisional hernia	1	5	0.059
Leak	0	0	
Cholelithiasis	3	8	0.061
Malnutrition	2	1	0.658
Bleeding	4	3	0.868
All	24	23	0.315

Roux limb did not improve the weight loss outcomes at 1 year of follow up and resulted in a higher incidence of internal hernias [11].

In our study, there was no difference in the incidence of internal hernia ($P = 0.373$); however, two complications (cholelithiasis and incisional hernia) approached statistical significance (Table 3). Feng et al. also did not find any significant effect on weight loss outcomes when they followed up two groups of patients with BMI <50 for 1 year. One group received short limb (45–100 cm) and the other group received extended limb (150 cm) [14]. Choban et al., in a 3-year prospective randomized clinical trial, compared the outcome of short Roux limb and long Roux limb bypass in patients with BMI less than 50 (75 vs. 150 cm) and in patients with BMI more than 50 (150 vs. 250 cm). There was no difference in weight loss between the two lengths in patients with a BMI less than 50 kg/m^2. In patients with BMIs greater than 50, those who underwent longer Roux limb bypass were more likely to lose at least 50% excess body weight. This difference was observed at 18 months but was lost at 24 and 36 months [13].

MacLean et al. found a statistically significant difference in weight loss among super-obese patients with longer-limb gastric bypass. Their follow-up was at 5.5 years; however, the short limb length or what used to be a standard length was 40-cm Roux limb and a 10-cm afferent limb. The long limb length was 100-cm Roux limb and a 100-cm afferent limb [16]. Bruder et al. had similar findings in the morbidly obese patients [18]. Brolin et al. also had close findings when the super-obese patients were evaluated [9].

As shown in Table 4, the short limb in these previously published studies ranged from 40 to 150 and the long limb ranged between 90 and 250. While the earlier reports were more likely to report a significant change in weight loss outcomes with an increase in the Roux limb length, the short limb length in these reports was much shorter than what is currently called short Roux limb. This significant variation in limb lengths between different studies may explain the disparity in results. It is possible that a 50-cm bowel length difference (200–250 cm) might not be sufficient to cause any significant energy malabsorption [19]. This can explain the lack of difference in weight loss observed in the present report. Interestingly, even in the case of the short lengths described before, Christou et al. found that the effect of increasing the length from 40 to 100 cm completely disappeared at 10 years.

With all these conflicting data, our study was designed to provide an answer to the optimal limb length in super-obese patients that would lead to a consistent weight loss outcome. The results of our study do not support the idea that increasing the Roux limb length from 150 to 200 cm will enable the patients to achieve more weight loss or will prevent more weight regain in this population. Weight regain is an important and serious issue after bypass surgery. This is the first study which compares weight regain between the two described variations of gastric bypass (SLL, LLL) and demonstrates that both groups regained weight and that increasing the limb length by 50 cm did not change the outcome. Our finding raises the question whether increasing the length more would provide the 'Holy Grail' to the problem of SO patients.

As shown in Table 3, when both groups were evaluated for any post-operative protein or calorie malnutrition, we did not observe any statistically significant difference between the two groups. This observation might be due to the sample size in this study, or a longer period of follow up might show a difference. Keeping in mind the complications reported before with the very long limb gastric bypass [20], we do not think that increasing the length from 200 to 250 cm is justified in SO patients.

Racial differences with obesity have been explored previously in the literature. When the percentage of excess weight loss 1 year after gastric bypass was compared between Hispanic and White subjects, there was no significant difference between both groups in the experience of Gustavo et al. [21]. However, in a recent publication comparing race as a predictor of weight loss, it was found that being Caucasian predicted success in weight loss after RYGBP [22]. Similarly, with Capella et al., Hispanic females lost significantly less weight compared with White females after vertical banded gastroplasty, but this difference was not significant when both males and females were included. In addition, when they compared the differences in weight loss outcomes after vertical banded gastroplasty–gastric bypass, ethnicity was not one of the weight loss predictors [23]. The majority of our patients were Hispanic females 82%. We did not see any difference in weight loss outcomes between this ethnic group and the reported literature in both the LLL and the SLL groups.

Table 4 Review of previous studies

Study	Roux limb length		*N*, number of patients	Follow-up, months	Pre-operative BMI	Weight loss	Design	Year
	Short	Long						
Ciovica	100	150	137	12	>50	Long limb lost more weight	Retrospective	2008
Pinheiro	150	250	105	48	>50	EWL was faster in the long limb group but was similar in both groups at 4 years of follow-up	Prospective randomized	2008
Lee	100	150	97	12	35–>50	Linear relationship between the reduction in BMI and the increasing Roux limb length	Prospective nonrandomized	2006
Christou	40	100	128 100	120	<50 >50	Only in SO. The long limb had modest but not significant improvement at 5 years in the SO. The difference was no longer seen at 10 years	Retrospective	2006
Inabnet	100	150	48	12	<50	Long limb did not improve weight loss outcomes	Prospective randomized	2005
Feng	45–100	150	58	12	<50	Long limb did not improve weight loss outcomes	Retrospective	2003
Choban	75 150	150 250	69 65	36	<50 >50	Only in SO; longer Roux limb bypass was more likely to lose 50% excess body weight. This difference was observed at 18 months but was lost at 24 and 36 months	Prospective randomized	2002
MacLean	40	100	146 96	66	<50 >50	Only SO patients did benefit from a long-limb bypass	Retrospective	2001
Brolin	75	150	45	43	>50	Weight loss was greater at 24 through 36 months in the long limb group	Prospective randomized	1992
Bruder	45	90	55	3–12	<50	Doubling the length increased the EWL by approximately 6%	Retrospective	1991

The limitations of this study include being a retrospective review and the sample size of 120 may not be large enough to detect the difference between both groups. Additionally, the follow-up period was only 3 years. As weight regain has been reported after 3 years, it might be possible that a longer follow-up period might result in a significant weight difference between the two groups. The fact that those patients who received SLL bypass were all operated after 2006 and those who received LLL were operated prior to 2006 might have affected the accuracy of our results. The patients in the LLL were more likely to reach 3 years of follow-up. Additionally, improved technical skills and the bariatric service experience could possibly be also confounding factors. One important limitation that we see in our study and in multiple previous studies is that the common channel length was not part of the equation in evaluating the outcome. This limb length may vary significantly between patients and it may play an important role in these patients' outcome.

Conclusion

This study suggests that increasing the Roux limb length from 150 to 200 does not result in any differences in weight loss or weight regain 3 years after RYGP. It is possible that a longer limb gastric bypass is not required in patients with BMI >50 kg/m^2 to obtain long-term, sustained weight loss. However, with the available conflicting literature, further studies about the longer limb gastric bypass and better weight loss outcomes in super-obese patients are still needed.

Conflicts of interest None of the authors has any conflicts of interest.

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