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ORIGINAL CONTRIBUTIONS

Comparing a Short Biliopancreatic Limb to a Long Biliopancreatic Limb in Patients with a Roux-en-Y Gastric Bypass with 4 Years Follow-up

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Abstract

Introduction In order to design the most effective weight loss procedure, the ideal biliopancreatic limb (BPL) and alimentary limb (AL) length in Roux-en-Y gastric bypass (RYGB) have been discussed extensively. Yet, no consensus has been reached. The aim of this study was to compare weight loss after a short and long BPL in patients who underwent a RYGB with a minimum of 4 years follow-up.

Methods This retrospective cohort study consisted of 574 patients who underwent a primary RYGB procedure between March 2015 and January 2017. Patients were divided in two groups based on the surgical procedure performed: a short BPL group (BPL of 50 cm with an AL of 150 cm) and long BPL group (BPL of 150 cm with an AL of 75 cm). The percentage total weight loss (%TWL) between groups was compared up to 4 years after surgery. Secondary outcomes were 30-day postoperative complications and health-related quality of life (RAND-36).

Results The short BPL group consisted of 286 patient and the long BPL group of 288 patients. Follow-up rates of both groups at the first, second, third, and fourth year after surgery were comparable. The long BPL group showed significantly more %TWL compared to the short BP limb group starting at 6 months ($p = 0.004$) until 4 years after surgery ($p < 0.001$). Thirty-day complications and health-related quality of life did not differ.

Conclusion The results showed significantly more %TWL in patients receiving a long BPL compared to the short BPL up to 4 years after surgery.

Keywords Roux-en-Y gastric bypass · Weight loss · Biliopancreatic · Limb length

Introduction

The Roux-en-Y gastric bypass (RYGB) is an effective procedure with a combination of restrictive and malabsorptive elements. Through the years, different modifications have been applied to the original laparoscopic gastric bypass (RYGB) procedure to optimize outcome [1]. One way to enhance weight loss is by altering the length of the alimentary limb (AL) and biliopancreatic limb (BPL) [2–7]. The limb lengths have been discussed extensively but no consensus about the ideal length of the limbs has been reached.

The effect of extending the length of the AL to increase the malabsorption has been studied extensively in the early years. Most studies only found small and non-significant weight loss increment after extending the AL length beyond 150 cm [4, 7–10]. An extremely long AL length of 200 cm or more seems to improve weight loss, but is also associated with significantly more malnutrition including severe vitamin deficiencies and diarrhea [11, 12]. After disappointing results of extending the AL, focus shifted to altering the BPL length. However, the effect of increasing the BPL length has been studied to a much lesser extent [13–16]. One of the first large studies investigating a longer BPL was the Elegance trial which started patient accrual in 2012 [15]. This randomized controlled trial compared a long BPL (150 cm) to their standard short BPL (75 cm) with a combined length of the BPL and AL of 225 cm in both groups. The study showed significantly more total (%TWL) and excess weight loss (%EWL) using the long BPL compared to the standard

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procedure until 3 years of follow-up. However, this effect in %TWL did not remain significant after 4 years [15].

Following these encouraging results, the long BPL was introduced for RYGB in our center from 2017 until now. The aim of this study was to compare weight loss after a short and long BPL in patients with a RYGB with a minimum of 4 years follow-up. Secondary outcomes were 30-day postoperative complications and health-related quality of life using Rand-36 questionnaire [17].

Methods

This study was a retrospective study of patients who underwent a laparoscopic Roux-en-Y gastric bypass (RYGB) between March 2015 and January 2017 at a single high-volume institution in the Netherlands, during which period a transition from standard short to long BPL in all RYGB procedures was introduced. Only patients undergoing a primary RYGB were selected for analysis. Between march 2015 and January 2016, patients underwent a RYGB with a short BPL of 50 cm and an AL of 150 cm (= short BPL group). From April 2016 until January 2017, patients underwent RYGB with a long BPL of 150 cm and an AL of 75 cm (= long BPL group). Between both periods, there was a transition phase of 2 months in which both surgical variations were performed. The patients from this period were excluded from the study.

Ethical Approval

Study approval of the local ethical committee was obtained. Formal informed consent of individual patients was considered not necessary since data was extracted from an existing prospectively maintained and anonymized database.

Perioperative Management

All patients were screened for eligibility following IFSO criteria valid at the time of surgery [18]. Preoperative assessment included examination by a dietician, internal medicine physician, pulmonologist, and psychologist. Several diagnostic tests including poly(somno)graphy for sleep apnea, a helicobacter pylori fecal test, and blood tests were scheduled before surgery and additional therapy or treatment was initiated if necessary. All patients entered a 6-week preoperative group-based lifestyle program or attended an individual lifestyle program which included both dietary and psychological sessions.

After surgery, patients entered a postoperative lifestyle program with twelve appointments scheduled during the first 18 months after surgery. Thereafter, patients were offered annual medical check-ups until the fifth year after surgery.

Surgical Techniques

All patients included were treated by certified and experienced bariatric surgeons. The technical procedure of the RYGB was standardized and consisted of the following steps. First, the stomach was mobilized and a small pouch size of 30–50 mL was created with the linear stapler. The anastomosis of the gastro-jejunostomy and the jejuno-jejunostomy was created using a linear stapler after defining the length of the AL and BPL. The length of both limbs were estimated by the surgeon counting steps of 5 cm after visually determining the first step of 5 cm. The common channel length was not measured standard in both study groups.

Statistical Analysis

Data was analyzed using IBM SPSS Statistics version 22.0. Categorical data were expressed in number (n) and percentage (%). Continuous data were expressed in means and standard deviation ($\pm$) or median with range, depending on the distribution. Data was tested for normality using histograms and Q-Q plots. Weight measures were recorded and displayed in absolute weight (kg), change in body mass index (ΔBMI) loss (kg/m^2), %TWL, and %EWL. Homogeneity of variance was tested using Levene's test. Categorical variables were analyzed using the chi-square test. Weight parameters and Rand-36 subscores of both groups at different time points after surgery were analyzed and compared using independent t-tests for continuous variables. All tests were two-tailed and a p value of $p \leq 0.05$ was considered statistically significant.

Results

There were 286 patients in the short BPL group and 288 patients in the long BPL group. Demographic characteristics were comparable between groups, without significant differences. Baseline characteristics are shown in Table 1.

Weight Outcomes of the Short BPL and Long BPL Group

Mean absolute weight in kg, BMI change in kg/m^2, percentage excess weight loss (%EWL), and percentage total weight loss (%TWL) for each time point are displayed in Table 2. Follow-up rates for the first, second, third, and fourth year were 262 (92%), 208 (73%), 172 (60%), and 139 (49%) in the short BPL group and 271 (94%), 219 (76%), 184 (64%), and 121 (42%) in the long BPL group, respectively. Table 3 displays the mean absolute weight, ΔBMI, %TWL, and %EWL

Table 1 Baseline characteristics of all patient ($n=574$)

	Short BPL ($n=286$)	sd	Long BPL ($n=288$)	sd	*P* value
Age in years	42.9	±12.1	44.7	±11.9	.068‡
Female (%)	228 (49.2)		235 (50.8)		.569†
Height in meters	1.68	±.09	1.68	±.09	.857‡
Weight in kg	125	±20.2	122	±19.7	.206‡
BMI in kg/m^2⁑	43 (33.6–67.3)		42 (32.2–72.4)		.073§
Hypertension (%)	83 (48.3)		89 (51.7)		.623†
Dyslipidemia (%)	44 (15.4)		63 (21.9)		*.046†*
Diabetes (%)	63 (53.4)		55 (46.6)		.385†
OSAS (%)	188 (50.4)		185 (49.6)		.707†
Osteoarthritis (%)	228 (50.1)		227 (49.9)		.790†
Operation time	63.9	±24.5	58.9	±18.16	*.002‡*
Admission days⁑	2 (1–103)		2 (1–18)		.786§

BPL, biliopancreatic limb; *sd*, standard deviation; *kg*, kilogram; *BMI*, body mass index; *OSAS*, obstructive sleep apnea

⁑Median (min–max). *P* values of $p<0.05$ are considered statistically significant and displayed in italic

†χ^2, ‡independent-samples *t* test, §Mann–Whitney *U*

with the accompanying *p* values at each time point. Overall, patients in the long BPL group achieved significantly more %TWL starting from 6 months ($p=0.004$) after surgery until 4 years after surgery ($p<0.001$). Maximum difference in %TWL was seen at 18 and 24 months after surgery.

Comparing %TWL of Patients with BMI Above 50

A subanalysis of patients with BMI above 50 was performed (Table 3). A total of 37 patients were included in the short BPL and 34 patients in the long BPL group. Both groups were comparable at baseline in gender, age, length, and preoperative weight (data not shown). The %TWL in the long BPL group was higher at each time point but not significantly different.

Complications

Postoperative complications (30-day) were seen in 25 patients (9%) in the short BPL group and 23 patients (8%) in the long BPL group, with no significant difference between groups ($p=0.744$). Table 4 shows the different 30-day complications of both surgical groups.

Health-Related Quality of Life

Mean subscores of the Rand-36 and the aggregated physical and mental scores at baseline, year 2, and year 4 of both groups are displayed in Table 5. There were no significant differences in scores between the short and long BPL groups at any time point.

Discussion

The aim of this study is to compare outcome of patients undergoing RYGB with a short BPL and long BPL with a minimum of 4 years follow-up. The results of the present study demonstrated a significant difference in %TWL between the short and long BPL groups up to 4 years after surgery. The difference in %TWL after 4 years was 3% higher in the long BPL compared to the short BPL variation. Complication rates and health-related quality of life showed no significant differences between groups.

The present findings are in line with the Elegance trial, an RCT performed by Homan et al., which randomized a total of 146 patients into either a long biliopancreatic limb group consisting of 72 patients (BPL 150 cm and AL 75 cm) or a short biliopancreatic limb group consisting of 74 patients (BPL 75 cm and AL 150 cm). Their results showed that after 12 months weight, BMI, %EWL, and %TWL all were significantly higher in the long BPL group up to 2 years after surgery. However, after 3 and 4 years after surgery, the difference in %TWL did not remain significant, $p=0.087$ and $p=0.152$ respectively. This could be potentially explained by the relatively smaller sample size in the Elegance trial. Our results show an average of 30% and 35% in the short and long BPL groups after 2 years, which is somewhat comparable to the 31% and 35% in the Elegance short BPL and long BPL group. In accordance with the trial, we found no significant differences in Rand-36 scores between the two limb variations. One difference between the present study and the Elegance trial is the shorter combined limb length of the short BP group. The length of 200 cm compared to 225 cm is due to a shorter length of 50 cm used in the present study.

Table 2 Weight outcomes after short BPL and long BPL gastric bypass ($n=574$)

	$n=286$			sd	$n=288$			*P* value‡
	Time point	Follow-up *n* (%)	Short BP		Follow-up *n* (%)	Long BP	sd	
Weight (kg)	Baseline	286 (100)	125	±20	288 (100)	122	±20	.206
	3 months	278 (97)	101	±18	277 (96)	99	±17	.162
	6 months	275 (96)	94	±16	279 (90)	90	±16	*.017*
	9 months	270 (94)	89	±16	273 (95)	84	±15	*<.001*
	12 months	262 (92)	87	±16	271 (94)	82	±14	*<.001*
	18 months	215 (75)	85	±15	224 (78)	80	±14	*<.001*
	24 months	208 (73)	87	±16	219 (76)	81	±15	*<.001*
	36 months	172 (60)	88	±17	184 (64)	81	±14	*<.001*
	48 months	139 (49)	91	±17	121 (42)	84	±14	*<.001*
ΔBMI (kg/m^2)	3 months	278 (97)	8	±2	277 (96)	8	±2	.520
	6 months	275 (96)	11	±3	279 (90)	11	±3	.060
	9 months	270 (94)	12	±3	273 (95)	13	±4	*.001*
	12 months	262 (92)	14	±4	271 (94)	15	±4	*.001*
	18 months	215 (75)	15	±4	224 (78)	15	±5	*.012*
	24 months	208 (73)	13	±5	219 (76)	14	±5	*<.001*
	36 months	172 (60)	13	±5	184 (64)	14	±4	*.039*
	48 months	139 (49)	12	±5	121 (42)	13	±2	*.025*
%EWL	3 months	278 (97)	46	±14	277 (96)	48	±16	.135
	6 months	275 (96)	60	±17	279 (90)	65	±19	*.001*
	9 months	270 (94)	69	±20	273 (95)	78	±21	*<.001*
	12 months	262 (92)	73	±20	271 (94)	81	±21	*<.001*
	18 months	215 (75)	76	±22	224 (78)	84	±22	*<.001*
	24 months	208 (73)	73	±23	219 (76)	83	±22	*<.001*
	36 months	172 (60)	70	±23	184 (64)	80	±21	*<.001*
	48 months	139 (49)	65	±24	121 (42)	70	±23	*<.001*
%TWL	3 months	278 (97)	19	±5	277 (96)	19	±4	.805
	6 months	275 (96)	25	±5	279 (90)	26	±5	*.004*
	9 months	270 (94)	28	±6	273 (95)	31	±6	*<.001*
	12 months	262 (92)	30	±7	271 (94)	32	±7	*<.001*
	18 months	215 (75)	31	±7	224 (78)	34	±8	*<.001*
	24 months	208 (73)	30	±8	219 (76)	34	±9	*<.001*
	36 months	172 (60)	29	±8	184 (64)	33	±9	*<.001*
	48 months	139 (49)	27	±9	121 (42)	30	±9	*<.001*

BPL, biliopancreatic limb; *sd*, standard deviation; *kg*, kilogram; *ΔBMI*, change in body mass index; *%EWL*, % excess weight loss; *%TWL*, % total weight loss

P values of $p<0.05$ are considered statistically significant and displayed in italic

‡Independent-samples *t* test

Table 3 Percentage TWL of patient with BMI > 50 ($n=71$)

	Time point	$N=37$			$N=34$			*P* value‡
		Follow-up *n* (%)	Short BPL	sd	Follow-up *n* (%)	Long BPL	sd	
%TWL	3 months	35	18	±4	31	27	±3	.359
	6 months	35	24	±5	34	25	±5	.463
	9 months	33	28	±6	31	31	±7	.109
	12 months	30	30	±7	31	33	±8	.120
	18 months	24	33	±8	24	36	±9	.177
	24 months	22	33	±9	27	37	±9	.103
	36 months	20	33	±10	17	36	±11	.355
	48 months	18	29	±12	12	32	±10	.651

BPL, biliopancreatic limb; *sd*, standard deviation; *%TWL*, % total weight loss

P values of $p<0.05$ are considered statistically significant and displayed in italic

‡Independent-samples *t* test

Table 4 Postoperative 30-day complications

Type of complication	Short BPL ($n=286$)	Long BPL ($n=288$)	*P* value
Any complication	25	23	.744‡
Bleeding	8	13	
Pneumonia	1	4	
Anastomotic leakage	5	4	
GERD	2	0	
Wound infection	1	1	
Dysphagia	2	0	
Perforation	0	1	
GJS stenosis	2	0	
Internal herniation	0	1	
Thromboembolic event	1	1	
Intra-abdominal abscess	2	0	

BPL, biliopancreatic limb; *GERD*, reflux; *GJS*, gastrojejunostomy

P values of $p<0.05$ are considered statistically significant and displayed in italic

‡Independent-samples *t* test

This difference of 25 cm in total length may have strengthened the effect of the longer BPL compared to the short BPL as stated by Homan et al. in their discussion. A recently retrospective analysis by Smelt et al. of 100 patients after RYGB of whom 50 patients had a BPL of 75 cm and an AL of 150 cm and 50 patients had a BPL of 150 cm and an AL of 75 cm similarly showed that patients with a BPL of 150 cm had more %EWL an %TWL up to 2 years after surgery but also found significantly more diarrhea and steatorrhea compared to a group with a BPL of 75 cm [16].

Another RCT by Nergaard et al. compared a gastric bypass with a 2-m BP limb and a AL of 60 cm showed better weight loss than a gastric bypass with a 60-cm BP limb and a 150-cm AL [19]. An RCT by Ruiz-Tovar et al. compared the effect of a BPL length of 70 cm vs 120 cm with a constant AL of 150 cm and did not find greater weight loss in the extended BPL variant [13]. These previously described limb lengths obviously differ from the lengths used in the present study. A systematic review published in 2010 by Stefanidis et al. concluded that altering the alimentary limb length has no clinical significant effect on weight loss for patients with BMI under 50; however, they suggested that an increased AL length of 150 cm or longer was associated with a modest weight loss advantage in patients with a BMI above 50 [8]. The subanalysis of 71 patients with BMI above 50 in the present study showed a trend towards more weight loss in the long BPL group but this was not significant. Yet, this analysis in a relatively small group of patients with BMI > 50 was possibly underpowered. A systematic review on limb lengths concluded that maximum weight loss is achieved when the combined length of the BPL and AL is between 100 and 200 cm [20]. This systematic review only evaluated one RCT study with a BPL length of more than 100 cm, i.e., 200 cm that showed significant superior weight loss compared to a BPL length of 60 cm [19]. The results of the present study showed superior weight loss outcomes in the variation with a combined length of 225 cm which exceeds the recommended 200 cm for the combined length by Mahawar et al. and the established recommendation of the international consensus meeting (BMSS-WOCOM held in 2018) for standardization of bariatric surgical procedures

Table 5 Rand-36 scores

	Short BPL preop	Long BPL preop	*P* value	Short BPL 2 years	Long BPL 2 years	*P* value	Short BPL 4 years	Long BPL 4 years	*P* value
Physical functioning	54.5	54.4	.978‡	86.4	86.7	.916‡	77.3	83.2	.110‡
Role functioning/physical	78.6	80.4	.575‡	79.7	82.5	.419‡	71.6	75.0	.495‡
Role functioning/emotional	80.4	78.6	.599‡	79.6	83.6	.248‡	75.1	79.0	.495‡
Energy/fatigue	50.8	51.2	.844‡	60.2	62.8	.210‡	56.3	61.4	.106‡
Emotional well-being	72.2	73.6	.346‡	75.4	76.2	.682‡	72.8	76.1	.271‡
Social functioning	68.4	69.9	.532‡	79.1	81.7	.313‡	75.0	77.5	.533‡
Pain	59.1	56.6	.282‡	78.4	77.0	.610‡	73.1	74.4	.746‡
General health	45.6	47.4	.311‡	69.5	72.2	.155‡	63.9	65.1	.690‡
Health change	40.0	40.9	.699‡	70.5	71.6	.688‡	50.4	57.1	.083‡
Total physical health	53.0	53.3	.865‡	78.6	76.1	.590‡	71.5	74.6	.400‡
Total mental health	67.6	68.7	.530‡	73.6	76.1	.236‡	69.9	73.5	.281‡

BPL, biliopancreatic limb; *preop*, preoperative

Scores are presented as mean subscores. *P* values of $p<0.05$ are considered statistically significant and displayed in italic

‡Independent-samples *t* test

which states the BPL and AL length of the RYGB should range between 50 and 150 cm with a maximum combined length of 200 cm [21].

An explanation for significantly increased weight loss in the long BPL group compared to the short BPL group could be simply caused by the larger part of the small intestines being bypassed which leads to a shorter "feeding" track, resulting in less absorption surface and shorter time for food digestion. Another theory, the "hindgut theory" which was previously mentioned by Homan et al., could be the explanation for the positive weight loss effect of the long BPL [19]. This theory describes the effect of rapid exposure of food to a more distal part of the small intestines, resulting in upregulation of L-cells, which are held responsible for excretion of satiety hormones (GLP-1, PYY). Increased levels of these hormones are thought to improve glycemic control and result in better weight loss [22]. One may agree that the mechanism responsible for weight loss after bariatric surgery is rather complex and may not be solely based on volume restriction and limb configurations.

The present study has several limitations. Loss to follow-up in this retrospective cohort is high and may have caused selection bias due to loss of non-responders. Harper et al. in 2007 demonstrated that patients who did not comply with regular follow-up care after laparoscopic RYGB have worse clinical outcome, i.e., less weight loss [23]. Therefore, the average weight loss at different time points may be lower for the entire population even though the outcome was comparable to the Elegance trial. Fortunately, loss to follow-up occurred equally in both groups and therefore it will probably have no effect on the study outcome. Another important limitation of this study was that we were only able to compare weight outcomes and quality of life of both groups but were unable to asses resolution of obesity-related comorbidities, micronutrient deficiencies, and gastro-intestinal symptoms, i.e., diarrhea or dumping after both variations of the RYGB. Especially since the BPL of 150 cm and AL of 75 cm seems to be accompanied by increased gastro-intestinal symptoms recording to the recently published study by Smelt et al. [16]. Despite the fact that these factors were not the primary aim of the study, these factors are important in the final decision of the ideal surgical procedure. In addition, the effect of the additional 25 cm of combined limb length in the long BPL compared to the short BPL group is unknown and may have contributed to the superior weight outcomes in the long BPL group.

An interesting and relatively new topic is the total alimentary limb length (TALL), which is the length of the AL combined with the common channel. Even though the common channel length can vary between 302 and 1050 cm in adult individuals, the TALL is often not measured during the RYGB procedure [5, 24]. Knowing the TALL could further allow surgeons to tailor the AL and BPL length and maintain a sufficient length without the risk of causing a short bowel syndrome. Yet, measuring the TALL has proven challenging and so far no accurate non-invasive diagnostic tool is available to assess the length of the small intestine before surgery and measuring the limb length during the procedure is considerably more difficult in an obese patient. In addition, we believe future studies should also include other postoperative outcomes than weight outcomes such as nutritional deficiencies, GI symptoms including diarrhea and steatorrhea, and reversals after the short and long BPL variations.

The present results suggest the long BPL variation results in significantly more weight loss than a short BPL variation from 6 months until 4 years after surgery; however, 2 or more years of follow-up are needed to see the final weight loss pattern after the short and long BPL. Future studies should focus on the TALL.

Declarations

Ethical Approval This study has been approved by the institutional research ethics committee and all procedures have been performed in accordance with the Declaration of Helsinki originally adopted in 1964 and its later amendments or comparable ethical standards. For this type of study, formal consent was not required.

Conflict of Interest The authors declare no competing interests.

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