ELSEVIER

Surgery for Obesity and Related Diseases xxx (xxxx) xxx

SURGERY FOR OBESITY AND RELATED DISEASES

Original article

A long biliopancreatic and short alimentary limb results in more weight loss in revisional RYGB surgery. Outcomes of the randomized controlled ELEGANCE REDO trial

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Received 13 July 2018; received in revised form 11 October 2018; accepted 13 October 2018; Available online xxx

Abstract

Background: For a number of years the laparoscopic adjustable gastric band has been one of the leading bariatric procedures with good short-term outcomes. However, inadequate weight loss, weight regain, and other band-related complications in the long term led to an increase in revisional Roux-en-Y gastric bypass (RYGB) procedures. Lengthening the biliopancreatic limb, a relatively simple and safe adjustment of the standard technique, could improve the results of the revisional procedure.

Objectives: The aim of this randomized controlled trial was to evaluate the effect of a long biliopancreatic limb RYGB (LBP-GB) and standard RYGB (S-GB) as revisional procedure after laparoscopic adjustable gastric band.

Setting: General hospital specialized in bariatric surgery

Methods: One hundred forty-six patients were randomized in 2 groups; 73 patients underwent an S-GB (alimentary/biliopancreatic limb 150/75 cm), and 73 patients underwent LBP-GB (alimentary/biliopancreatic limb 75/150). Weight loss, remission of co-morbidities, quality of life, and complications were assessed during a period of 4 years.

Results: Baseline characteristics between the groups were comparable. At 48 months the follow-up rate was 95%. Mean total weight loss after 24 months was 27% for LBP-GB versus 22% S-GB ($P = .015$); mean total weight loss after 48 months was 23% and 18%, respectively ($P = .036$). No significant differences in other parameters were found between the groups.

Conclusions: A LBP-GB as revisional procedure after a failing laparoscopic adjustable gastric band improves short- and long-term total weight loss compared with an S-GB. Together with future modifications this technically simple adjustment of the RYGB could significantly improve disappointing results after revisional surgery. (Surg Obes Relat Dis 2018;000:1–10.)

Key words: Morbid obesity; Bariatric surgery; Laparoscopic adjustable gastric band; Conversion; Redo; Roux-en-Y gastric bypass; Long biliopancreatic limb; Weight loss

For a number of years, the laparoscopic adjustable gastric band (LABG) has been a leading bariatric procedures with good short-term outcomes [1,2]. However, inadequate weight loss, weight regain, and other band-related complications in the long term led to a fast, worldwide decrease

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https://doi.org/10.1016/j.soard.2018.10.010
1550-7289/

in LAGB procedures [3,4]. Most failed LABG are converted to a Roux-en-Y gastric bypass (RYGB), as band removal alone results in weight regain and deterioration of co-morbidities in most patients, even when patients had reached an adequate weight loss at time of explantation [3,5–7]. The RYGB as revisional surgery can be technically demanding but can be performed with acceptable perioperative morbidity as a 1-stage procedure when performed by experienced surgeons [3]. Compared with better results after primary procedures, Fournier et al. [8] reported a total weight loss (TBWL) of 28% to 30% after 2 years of follow-up and Aarts et al. [3]. an excess weight loss of 53% after revisional RYGB. Patients who did not achieve sufficient weight loss with a LAGB seem to have a lower success rate after revisional RYGB compared with good responders after LAGB [9].

The basic design of the RYGB has hardly been changed since its introduction in 1966 by Mason [10], and a relatively longer alimentary (Roux) limb (AL) and a short biliopancreatic limb (BPL) are still used in most primary and revisional procedures [11]. Research from our center suggests that lengthening the BPL results in significantly more weight loss in primary RYGB (unpublished data). This advantage of a relatively simple and safe adjustment of the standard technique could improve the inferior results of the revisional procedure. To this date, no other studies have compared limb length in revisional surgery.

The aim of this single-blind, randomized controlled trial was to evaluate the effect of a long biliopancreatic limb RYGB (LBP-GB) and standard RYGB (S-GB) as revisional procedure after LAGB.

Methods

The protocol of this randomized, controlled, parallel-group, single-center trial was reviewed and approved by the central medical committee for research in humans in Nijmegen, the Netherlands, and registered at the clinical trials registry of clinicaltrials.gov (NCT 01686997). This study was conducted in accordance with the Declaration of Helsinki (originally adopted in 1964, with the last amendment before this trial in October 2008).

Patient selection

All adult patients (age ≥18 yr) with a failing LAGB due to insufficient weight loss, weight regain, or other band-related complication that were planned to be converted to a RYGB were approached and informed about trial design. After receiving explanation of the study setup, risks, and possible benefits during consultation and through a written information brochure, patients were given a 2-week time period to consider participation; written informed consent was documented thereafter. All patients were evaluated if inclusion and exclusion criteria according to the International Federation for the Sugery of Obesity and Metabolic Disorders (IFSO) guidelines (body mass index >40 or >35 kg/m^2 with the presence of at least 1 co-morbidity) were considered applicable by a multidisciplinary team, including a bariatric surgeon, nutritionist, psychologist, endocrinologist, and physiotherapist, before being fully approved for revisional surgery. A form of inflammatory bowel disease, language barrier, and renal dysfunction (Glomerular Filtration Rate (GFS) <30 min) were additional exclusion criteria for this study.

Primary and secondary endpoints

Primary endpoint of the study was %TBWL over a period of 4 years. The %TBWL was defined as weight loss divided by total weight before revisional RYGB. The weight before revisional surgery was used because weight loss due to revisional surgery was analyzed regardless of the initial weight before primary surgery. Secondary endpoints were reduction of obesity related co-morbidities (type 2 diabetes [T2D], hypertension [HT], and dyslipidemia [DL]), perioperative complications, and quality of life (QoL).

Surgical procedures/operation techniques

Standard revisional RYGB

Four experienced bariatric surgeons (>1000 RYGB cases) performed the procedures. A standardized operation technique was used in which the band was removed and an RYGB was performed. All revisional operations were performed laparoscopically. After introduction of the trocars in the abdominal cavity, adhesions were carefully released, and the anatomic structures were identified. On the anterior side, the band was released from the stomach, opened, and removed. Fibrotic tissue on the stomach due to the band was released by cleaving the fibrotic ring on the anterior side of the stomach. Distal of the former position of the band a gastric pouch was constructed using a linear stapler (Echelon, Ethicon; Johnson & Johnson, New Brunswick, NJ, USA). The BPL of 75 cm was measured from the ligament of Treitz using a tapeline under medium stretch along the mesenteric border. The AL was placed antecolic and antegastric and the end-to-side gastrojejunostomy was created using a linear stapler (ETS, Ethicon; Johnson & Johnson) combined with a running suture to close the stapling gap (V-loc; Medtronic, Minneapolis, MN, USA). The AL of 150 cm was measured with a tapeline under medium stretch, and a side-to-side enteroenterostomy was made using a 60-mm linear stapler combined with a running suture. The gastric pouch staple line and the gastrojejunostomy were tested intraoperative for integrity for leakage with an air leakage test and mesenteric defects were closed with a double layer of hernia staples (EMS, Ethicon; Johnson & Johnson).

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Long biliopancreatic limb revisional RYGB

The same standardized operation as described was performed, but with different limb lengths. A 150-cm BPL and a 75-cm AL were used. In both procedures a combined total length of 225 cm of small intestine was used for the BPL and AL.

Randomization

The local study coordinator performed the randomization of patients. A web-based randomization module (Research Manager; Nova Business Software, Zwolle, the Netherlands) with a 1:1 allocation ratio and concealed carrying permuted block size of 2 and 4 patients was used. Due to the invasive nature of the procedure and the logistics, investigators and surgeons were not blinded for group allocation. The patients, however, were not aware which procedure they had received during the operation or during the complete follow-up, making this a single-blind, randomized controlled trial.

The hypothesis that the LBP-GB leads to a 5% higher TBWL after 2 years was used for sample size calculation. Using 80% power, an alpha of 5%, a standard deviation of 10%, and considering 10% lost to follow-up, 70 patients were needed in both groups. Exactly 146 patients were randomized.

Assessment

Preoperatively, all patients underwent anesthesiologic screening and blood samples were taken, in which serum levels of ferritin, folic acid, vitamin B12, 25-hydroxyvitamin D, and parathyroid hormone were determined. When any deficiencies were detected, they were corrected before surgery.

To prepare patients for the different lifestyle required postoperatively, they followed obligatory sessions at the Dutch Obesity Clinic where they received nutritional, psychological, and physical counseling. In the postoperative phase these sessions continue until 6 years after surgery. Additionally, patients came for a medical control on a regular basis (6 weeks and 3, 6, 9,12, 18, and 24 months) after surgery. After 2 years the medical controls were scheduled annually. During these control visits the patients' weight, body mass index, medication use, eating habits, and blood values were assessed. Deficiencies in vitamins were defined as a value below the lower normal limit as stated in the American Society for Metabolic and Bariatric Surgery guidelines [12]. The Bariatric Analysis and Reporting Outcome System (BAROS) [13] and the RAND-36 were used to evaluate the changes in the QoL.

Obesity-related co-morbidities that were investigated were T2D, HT, and DL. T2D was defined as a fasting plasma glucose $\geq$7 mmol/L and/or glycated hemoglobin (HbA1C) $\geq$48 mmol/mol (HbA1C $\geq$6.5%) or the use of oral antidiabetic medication or insulin, HT was defined as the use of antihypertensive medication, and DL was defined as the use of statins. Changes in T2D were defined as remission when fasting glucose was <7 mmol/L, HbA1C was <48 mmol/mol (Hba1C <6.5%), and discontinuation of all T2D medication for at least a year was achieved. Improvement was defined as a reduction in treatment medication and as unchanged when no difference in the preoperative status was seen. Remission of HT was defined as remission when a discontinuation of medical treatment was achieved, improvement as reduction in treatment, and unchanged when there was no difference in the preoperative status. The same definitions for remission of DL were used. However, improvement is not a sensible outcome measure in DL because partial reduction of treatment is not really possible.

Postoperative medication and supplements

After the operation the patient started intake with clear liquids as soon as 2 hours after surgery. The first postoperative day oral feeding was expanded. Postoperative fraxiparin 5700 IU anti-XA once daily as thrombosis prophylaxis for 4 weeks and 20 mg of omeprazole for 7 months to protect the gastroenterostomy were prescribed. Patients were also prescribed specialized bariatric supplements for RYGB patients (FitforMe, Rotterdam, the Netherlands), 1500 mg calcium, and 2400 IU vitamin D3 lifelong on a daily basis.

Statistical analysis

All data were analyzed using IBM SPSS (version 21.0 Windows; Armonk, NY, USA). Primary and secondary outcomes are presented as mean values with standard deviation. Continuous variables were analyzed using an independent *t* test, and categorical data were analyzed using the Fisher exact test. All tests were 2-tailed, and a *P* value $<$ .05 was considered statistically significant.

Results

From July 2012 to December 2013, 146 adult patients with a failing LABG who were scheduled to undergo revisional RYGB were entered in the study. Seventy-three patients were randomized to undergo S-GB and 73 to LBP-GB. In both groups, 1 patient was excluded. In the S-GB group, 1 patient was excluded because during surgery it was found that the patient had not received an earlier LAGB in a different center despite the report in the medical file. In the LBP-GB group, 1 patient appeared to have an intestinal malrotation during surgery, making the scheduled LBP-GB impossible to perform. These protocol violations were excluded for the per-protocol analysis of the primary and secondary outcomes. In the intention-to-treat

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Table 1
Baseline patient characteristics

	S-GB	LBP-GB
Number of patients	72	72
Female, n (%)	57 (79)	61 (85)
Age, yr	47 ± 7	47 ± 9
Height, cm, mean ± standard deviation	170 ± 8	170 ± 9
Weight, kg, mean ± standard deviation	121 ± 16	123 ± 20
BMI, kg/m², mean ± standard deviation	42 ± 4	43 ± 5
BMI pre-LAGB, kg/m², mean ± standard deviation	47 ± 6	47 ± 6
Indication revision, n (%)		
Insufficient weight loss	10 (14)	12 (17)
Weight regain	55 (76)	48 (67)
Band intolerance	5 (7)	10 (14)
Band-related complications	2 (3)	2 (3)

S-GB = standard Roux-en-Y gastric bypass; LBP-GB = long biliopancreatic limb Roux-en-Y gastric bypass; BMI = body mass index; LAGB = laparoscopic adjustable gastric band.

Table 2
Weight loss parameters

		S-GB	SD	LBP-GB	SD	*P* value
%EWL, mo	12	59	23	66	21	.094
	24	58	27	67	26	**.045**
	36	51	29	61	29	**.043**
	48	47	28	57	32	.078
%TBWL, mo	12	23	8	26	9	**.021**
	24	22	10	27	11	**.015**
	36	20	11	24	12	**.014**
	48	18	10	23	12	**.036**

S-GB = standard Roux-en-Y gastric bypass; SD = standard deviation; LBP-GB = long biliopancreatic limb Roux-en-Y gastric bypass; EWL = excess weight loss; TBWL = total weight loss.
Bold values indicate statistical significance ($P < 0.05$)

analysis all patients were included. The baseline characteristics did not differ significantly between groups. The major reason for conversion of the LAGB to RYGB was weight regain, 67% in the S-GB group and 76% in the LBP-GB group (Table 1). At 48 months, the follow-up rate was 95%. Despite our persistent efforts 7 (5%) patients were lost to follow-up after 4 years (Fig. 1).

Weight loss

The LBP-GB group achieved a significantly higher percentage of TBWL after 6 months postoperatively. This significant difference was seen throughout the complete follow-up period of 4 years. After 24 months, both groups reached their maximum TBWL, 22% in the S-GB group and 27% in the LBP-GB group ($P = .015$). Although both groups regained weight, a significant difference in favor of the LBP-GB group was still seen after 4 years: 18% versus 23% ($P = .036$). The results of the weight parameters are shown in Table 2. When applying the intention-to-treat principle results remain significant at the same time points.

Table 3
Remission of co-morbidities

		S-GB	LBP-GB	*P* value
Type 2 diabetes (%)		15 (21)	9 (13)	.180
24 mo	Remission	10 (67)	7 (78)	.824
	Improvement	3 (20)	1 (11)	
	Unchanged	2 (13)	1 (11)	
48 mo	Remission	9 (60)	5 (56)	.791
	Improvement	2 (13)	1 (11)	
	Unchanged	1 (7)	0	
	Unknown	3 (20)	3 (33)	
Hypertension (%)		18 (25)	24 (33)	.271
24 mo	Remission	7 (39)	12 (50)	.332
	Improvement	5 (28)	2 (8)	
	Unchanged	6 (33)	9 (38)	
	Unknown	0	1 (4)	
48 mo	Remission	5 (28)	7 (29)	.587
	Improvement	4 (22)	3 (13)	
	Unchanged	3 (17)	8 (33)	
	Unknown	6 (33)	6 (25)	
Dyslipidemia (%)		13 (18)	7 (10)	.242
24 mo	Remission	9 (69)	5 (71)	.843
	Unchanged	4 (31)	2 (29)	
48 mo	Remission	8 (62)	4 (57)	.640
	Unchanged	5 (39)	3 (43)	

S-GB = standard Roux-en-Y gastric bypass; LBP-GB = long biliopancreatic limb Roux-en-Y gastric bypass.

Resolution of co-morbidities

The patients that achieved resolution of the most common obesity-related co-morbidities are listed in Table 3, and the changes in biochemical parameters and blood pressure are shown in Table 4.

Type 2 diabetes

At baseline, 24 (17%) patients were diagnosed with T2D, 15 (21%) in the S-GB group and 9 (13%) in the LBP-GB group. Both groups included patients with a glucose intolerance (fasting serum glucose ≥7 mmol/L and/or HbA1C ≥48 mmol/mol) at screening without using oral antidiabetic medication or insulin, 4 in the S-GB and 3 in the LBP-GB group. In 73% of the patients in the S-GB group and 67% in the LBP-GB group, surgery resulted in at least an improvement after 48 months. Remission of T2D 2 years after surgery, when maximum weight loss was achieved, was achieved in 67% in the S-GB and 78% in the LBP-GB ($P = .824$). No significant difference was found between the groups.

Hypertension

In the S-GB group, 21 (29%) patient were diagnosed with HT, and surgery resulted in remission in 5 (28%) patients after 48 months. In the LBP-GB group, 24 (33%) patients were diagnosed with HT, and remission occurred in 7 (29%). No significant difference was found between the groups after 48 months or after 24 months. The mean systolic and diastolic blood pressure significantly decreased

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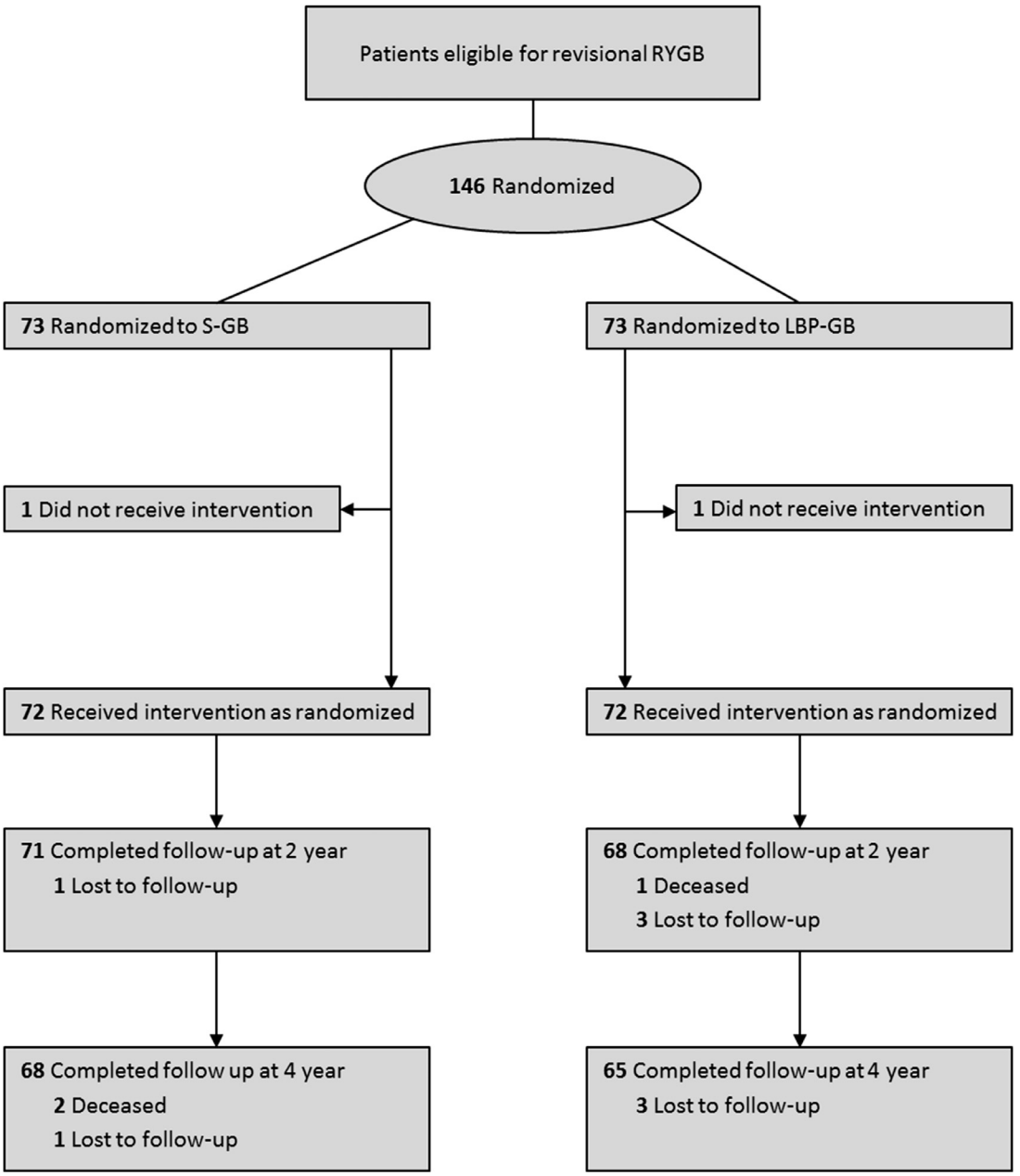

Fig. 1. Flow diagram: number of patients during follow-up.

in both groups without significant differences between the groups.

Dyslipidemia

Based on the use of statin, a total of 20 (14%) patients suffered from DL at baseline. After 4 years, 12 (60%) patients achieved remission, 8 (62%) in the S-GB group and 4 (57%) in the LBP-GB group. No significant differences in remission rate or improved lipid biochemical chemical parameters were found between the groups.

Complications

A total number of 14 (10%) patients suffered a short-term complication, 6 (8%) patients in the S-GB group versus 8 (11%) patients in the LBP-GB group ($P > 0.05$). In total, 3 (4%) patients underwent a reoperation. One anastomotic leakage occurred in both groups. One patient in the LBP-GB group underwent reoperation because of the suspicion of a bleeding; however, a focus was not found. All the short-term complications are listed in Table 5.

A long-term complication occurred in 30 (21%) patients, 15 patients in both groups. In total, 30 reopera-

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Table 4
Biochemical parameters and blood pressure

	S-GB			LBP-GB				
	Baseline	24 mo	48 mo	Baseline	24 mo	48 mo	*P* value*	*P* value†
Type 2 diabetes								
HbA1C, mmol/mol	55 ± 12	41 ± 7	43 ± 15	66 ± 25	44 ± 21	35 ± 6	**.041**	**.021**
Fasting glucose, mmol/L	8.1 ± 3.0	5.4 ± 1.3	5.8 ± 1.2	10.8 ± 3.7	6.2 ± 2.7	5.1 ± 0.6	**.022**	**.011**
Hypertension								
Systolic BP, mm Hg	146 ± 16	136 ± 18	139 ± 21	151 ± 19	145 ± 22	147 ± 22	**.015**	.305
Diastolic BP, mm Hg	93 ± 8	83 ± 13	89 ± 16	95 ± 11	86 ± 15	90 ± 11	**<.001**	.198
Dyslipidemia								
HDL cholesterol, mmol/L	1.28 ± .37	1.41 ± .31	1.42 ± .31	1.26 ± .35	1.41 ± .31	1.45 ± .32	**<.001**	**<.001**
Triglycerides, mmol/L	2.1 ± 1.3	1.3 ± .7	1.4 ± .7	2.2 ± 2.9	1.1 ± .5	1.1 ± .41	**.002**	**<.001**
LDL cholesterol, mmol/L	2.73 ± .92	2.32 ± .79	2.53 ± .78	3.10 ± .73	2.58 ± .93	2.66 ± .86	**.003**	.110

S-GB = standard Roux-en-Y gastric bypass; LBP-GB = long biliopancreatic limb Roux-en-Y gastric bypass; HbA1C = glycated hemoglobin; BP = blood pressure; HDL = high-density lipoprotein; LDL = low-density lipoprotein.
Values presented as mean ± standard deviation.
* Pre- versus 24-months postoperative scores of the total group.
† Pre- versus 48-months postoperative scores of the total group.

Table 5
Short- and long-term complications

	S-GB	LBP-GB	*P* value
Short term			
Total number of patients (%)	6 (8)	8 (11)	.780
Reoperation	3	3	
Leakage	1	1	
Bleeding	2	0	
Other	0	2	
Conservative treated bleeding	1	0	
Superficial wound infection	3	2	
Readmission	1	3	
Mortality	0	0	
Long term			
Total number of patients (%)	15 (21)	15 (21)	> 0.999
Reoperation	14	16	
Cholecystectomy	4	5	
Internal herniation	1	3	
Adhesion	2	2	
Suspicion of internal herniation	3	1	
Perforation gastroenterostomy	0	1	
Hernia cicatricalis	2	2	
Other	2	2	
Stomach ulcer	2	1	
Dysphagia	2	0	
Mortality	2	1	

S-GB = standard Roux-en-Y gastric bypass; LBP-GB long biliopancreatic limb Roux-en-Y gastric bypass.

tions were performed, most (9) of which were cholecystectomies, which is a common phenomenon after bariatric surgery. Four patients in both groups were reoperated because of a suspicion of an internal herniation, which was confirmed and corrected in 1 patient in the S-GB group and in 3 patients the LBP-GB group.

During the follow-up period, 3 patients (4%) died. In the S-GB group 1 patient died from a cerebral hemorrhage, and in the LBP-GB group 1 died as a result of a metastasized cervix carcinoma. In the S-GB group, 1 patient underwent a laparoscopy for reasons of weight regain and was converted to a distal RYGB. One week postoperatively this patient underwent a laparotomy because of a blow-out of the stomach remnant. Despite all efforts this patient developed multiorgan failure and died 2 weeks later. All long-term complications are listed in Table 5.

Nutritional status

The percentage of patients using multivitamins as prescribed according to protocol decreased from 62% after 2 year to 55% after 4 years. After 48 months, 66% of the nonusers developed a deficiency compared with 34% of the users according to protocol. The number of patients with a deficiency preoperative and after 2 and 4 years are listed in Table 6. No significant differences were found between the groups.

Quality of life

BAROS

The results of the BAROS scores are presented in Table 7. At the point of maximum weight loss at 2 years the mean BAROS score in both groups was 3.4 ($P > .05$). After 4 years, 80% of the patients had a result of fair or better with a mean BAROS score of 3.2 in the S-GB group and 3.0 in the LBP-GB group ($P > .05$).

RAND-36

A significant improvement in several domains is seen after 24 and 48 months in all patients compared with the preoperative values. Only after 24 months is there a significant difference between the S-GB group and the LBP-GB group in the domain physical functioning (*) in favor of the LBP-GB group. Results of the RAND-36 scores are presented in Fig. 2.

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Table 6
Nutritional and vitamin deficiencies

	S-GB			LBP-GB					
Deficiency %	Baseline	24 mo	48 mo	Baseline	24 mo	48 mo	*P* value*	*P* value†	*P* value‡
Hemoglobin	8	5	4	4	6	4	.494	.719	1.000
Folic acid	1	0	2	0	0	2	1.000	1.000	1.000
Vitamin B_{12}	19	19	15	21	20	9	1.000	.827	.572
Ferritin	22	24	29	11	22	29	.116	.836	1.000
Vitamin D	63	20	11	54	19	9	.307	1.000	1.000

S-GB = standard Roux-en-Y gastric bypass; LBP-GB = long biliopancreatic limb Roux-en-Y gastric bypass.
*Preoperative scores between the S-GB and LBP-GB group.
†24-month scores between the S-GB and LBP-GB group.
‡48-month scores between the S-GB and LBP-GB group.

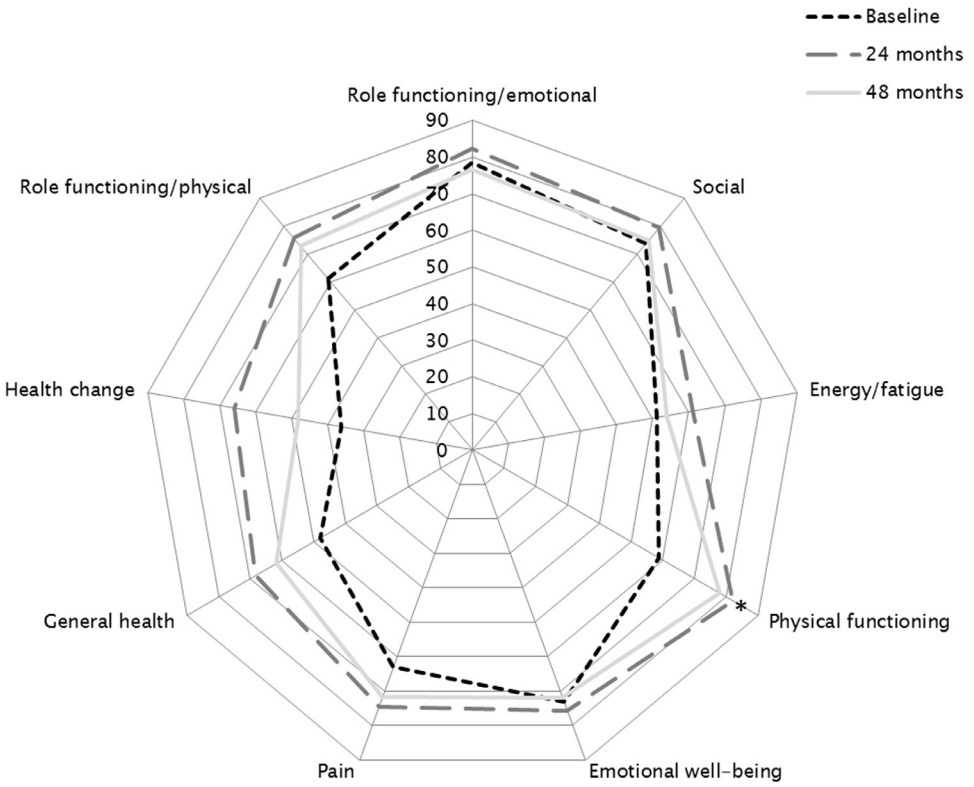

Fig. 2. *48-month scores between the standard Roux-en-Y gastric bypass and the long biliopancreatic limb Roux-en-Y gastric bypass groups were significantly different.

Discussion

Poor mid- and long-term results after LAGB resulted in an increase of revisional bariatric surgery worldwide [3,4]. To prevent weight regain after band removal or to obtain secondary weight loss, removal is often combined with conversion to another bariatric procedure, most often an RYGB [3,5–7]. It is notable that weight loss results after conversion of LAGB to RYGB are on average worse than after primary procedures [3,8]. The mechanisms leading to this observation are not fully understood, but one of the factors may well be patient selection; revision is often considered only after either insufficient weight loss or weight regain. To improve weight loss outcomes after revisional surgery an adjustment in RYGB design could help to produce results that are more pronounced and sustainable.

Gripping points for adjustments in RYGB design are limb lengths, pouch size, and gastroenterostomy passage by adding a nonadjustable gastric band [14–17]. For many years AL length has been held responsible for weight loss results after RYGB and therefore has been studied most. However, several randomized control trials and a systematic review on AL limb length show that lengthening the AL does not result in additional weight loss after RYGB, except possibly in 1 selected group of patients with body mass index >50 kg/m^2 [14].

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Table 7
BAROS score

	S-GB	LBP-GB	*P* value
BAROS 24 mo postoperative			
Excellent	3%	0	.981
Very good	28%	29%	
Good	39%	26%	
Fair	10%	34%	
Failure	21%	11%	
BAROS 48 mo postoperative			
Excellent	6%	0%	.822
Very good	22%	18%	
Good	22%	31%	
Fair	31%	33%	
Failure	19%	18%	

S-GB = standard Roux-en-Y gastric bypass; LBP-GB = long biliopancreatic limb Roux-en-Y gastric bypass; BAROS = bariatric analysis and reporting outcome scale.

The length of the BPL is studied to a much lesser extent. Exceptionally good weight loss is described in some non-randomized studies, but most studies lack sufficient standardization and follow-up [15,18,19]. To our knowledge, this is the first study in which the length of the BPL in revisional RYGB is studied and, moreover, the first randomized controlled trial in which results of revisional surgery after a failed LAGB are described.

In this randomized control trial a significantly better %TBWL was seen from 6 months to 4 year postoperatively, with a maximum of 27% in the LBP-GB group versus 22% in the S-GB group after 24 months. The %TBWL after both LBP-GB and S-GB at 2 years in the present studies is high compared with results after revisional surgery published in literature. A possible explanation could lie in the fact that even for our S-GB an already relatively long BPL of 75 cm is used, which is more than in most other studies [3,8].

A possible explanation for the above-average results in the LBP-GB group could be a more pronounced hindgut effect that arises with lengthening of the BPL. Due to the delivery of nutrients to a more distal L-cell rich part of the small intestine an increased postprandial glucagon-like protein-1 response arises [20,21], which theoretically reduces appetite and gastrointestinal motility, eventually leading to better weight loss in the LBP-GB group. Alternatively, the results in the LBP-GB group could be explained using the foregut hypothesis. Creating a longer BPL results in a larger part of the small intestine that is excluded from ingested nutrients, with the result of decreased production of foregut hormones that contribute to the development of obesity and diabetes [22].

Results of this study raise the question of whether an even longer BPL of 200 to 250 cm would also lead to even more weight loss, yet an ideal length for all limbs is still a matter of debate. However, it should be kept in mind that that at some point the total length of excluded intestine would lead to a short common channel and subsequent malabsorptive issues. In the present study, the mean length of the common channel was 395 cm (measured in 27% of the patients), leaving room for a longer BPL in most cases, especially if combined with a shorter AL. As AL limb length does not seem to influence weight loss, a minimum of 60 cm to prevent reflux theoretically suffices.

Although a significant difference is found in weight loss between the groups, this study fails to demonstrate a significant difference in secondary outcomes, such as remission of T2D, HT, and DL. This is in contrast with literature in which an improved remission of co-morbidities is found when weight loss increases [23–25]. However, this study was powered for weight loss and is probably underpowered for finding significant differences in these secondary endpoints. Still, the results of the remission of especially T2D and HT in this study are good compared with other studies reporting results after revisional surgery.

The LBP-GB is not technically more difficult to perform, which is illustrated by comparable complication rates in both groups. Although revisional surgery after a failed LAGB seems safe, a higher complication rate compared with primary procedures is described [26]. In this study, a complication rate of 21% in both groups seems high, but that is partly attributed to the fact that cholecystectomy is counted as a complication after bariatric surgery. When cholecystectomies are excluded, the overall complication rate in this study decreases to 15%, which is in line with results from the literature. In the past it was suggested that lengthening the BPL results in a higher incidence of internal herniation. The total number of only 4 cases in this study does not seem to confirm that claim.

Theoretically, lengthening the BPL could lead to more vitamin and mineral deficiencies due to exclusion of a longer part of duodenum and proximal jejunum. Ferritin uptake, for example, takes place in the first part of the small intestine. However, no differences in deficiencies were found between the procedures during follow-up. Although only 55% of patients were using the specialized multivitamins as prescribed after 4 years, no increase in the total number of deficiencies was seen. This may be a result from the fact that patients with established deficiencies during follow-up received additional supplementation. It is very likely that possible differences between groups were corrected in this way.

Weight loss after bariatric surgery is associated with improvement of QoL, especially where the physical aspects are concerned [27]. In this study, the RAND-36 showed significant improvement in almost all physical domains after 24 and 48 months. In contrast to the significant difference in weight loss found in this study, no differences were seen between groups in QoL using the BAROS score, not even after 2 years when weight loss was at its high point. Perhaps the slightly inferior weight loss results, only considered in the BAROS score, compared with primary

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RYGB patients and the already adjusted expectations of bariatric surgery in revisional RYGB patients could play a role in this.

Patients with an LAGB who are eligible for revisional surgery often have a history of severe symptoms or disappointing results before revisional surgery. Given that revisional surgery on average has worse outcomes in terms of weight loss, it seems wise to manage unrealistic expectations in the early phase. It is questionable if an additional 5% TBWL, which roughly translates to a weight of 5 kg, has great clinical relevance. However, limb lengths are not the only gripping point for RYGB adjustment. Other factors, such as pouch design, length, and pouch-banding, are studied in a primary RYGB randomized control trial in our center, in a search for the optimal design (ClinicalTrials.gov number NCT02218957 and NCT02545647). Also, the diameter of the gastrojejunal anastomoses could be the subject of debate. When proven effective in primary RYGB patients all adjustment together may further improve weight loss in revisional RYGB surgery.

Conclusion

A LBP-GB as revisional procedure after a failing LAGB improves short- and long-term TBWL compared with an S-GB. Together with future modifications this technically simple adjustment of the RYGB could significantly improve disappointing results after revisional surgery.

Disclosure

The authors have no commercial associations that might be a conflict of interest in relation to this article.

Appendix. : Weight loss parameters

		S-GB	sd	LBP-GB	*sd*	*p*-value
Weight, kg	Baseline	121	16	123	20	0.461
	6 weeks	111	14	112	19	0.668
	3 months	105	14	105	17	0.919
	6 months	99	15	97	15	0.552
	9 months	95	16	93	15	0.296
	12 months	93	16	90	15	0.216
	24 months	94	18	89	16	0.132
	36 months	97	19	92	17	0.109
	48 months	98	19	94	18	0.185
BMI, kg/m²	Baseline	42	4	43	5	0.338
	6 weeks	38	4	39	5	0.598
	3 months	36	4	36	5	0.879
	6 months	34	4	34	4	0.516
	9 months	33	5	32	4	0.212
	12 months	32	5	31	4	0.171
	24 months	33	6	31	5	0.072
	36 months	34	6	32	5	0.080
	48 months	34	6	33	6	0.170
%EWL	6 weeks	21	9	23	12	0.232
	3 months	33	12	36	13	0.153
	6 months	47	16	52	16	0.078
	9 months	55	21	61	19	0.068
	12 months	59	23	66	21	0.094
	24 months	58	27	67	26	**0.045**
	36 months	51	29	61	29	**0.043**
	48 months	47	28	57	32	0.078
%TBWL	6 weeks	8	3	9	4	0.227
	3 months	13	4	14	4	0.072
	6 months	18	6	21	6	**0.021**
	9 months	21	7	24	8	**0.016**
	12 months	23	8	26	9	**0.021**
	24 months	22	10	27	11	**0.015**
	36 months	20	11	24	12	**0.014**
	48 months	18	10	23	12	**0.036**

S-GB standard Roux-en-Y gastric bypass, *LBP-GB* long biliopancreatic limb Roux-en-Y gastric bypass, *BMI* Body Mass Index, *EWL* excess weight loss, *TBWL* total body weight loss, *sd* standard deviation

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