Obesity Surgery (2019) 29:3665–3671
https://doi.org/10.1007/s11695-019-04051-8

ORIGINAL CONTRIBUTIONS

Outcomes of Long Pouch Gastric Bypass (LPGB): 4-Year Experience in Primary and Revision Cases

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Published online: 2 July 2019

Abstract

Background One of the most important complications of the one anastomosis gastric bypass (OAGB) is enterobilio acid reflux (EBAR). We report the concept of the long pouch Roux-en-Y gastric bypass (LPRYGB) meaning a Roux-en-Y with a long pouch and a 100-cm alimentary limb to avoid EBAR, with a long biliopancreatic limb to increase metabolic effects.

Methods A total of 300 LPRYGB cases in a 4-year period, with a 90% follow-up rate, were analysed. Anthropometric, technical feasibility, morbidity, weight loss and comorbidity outcomes were analysed.

Results The percentage total weight loss (%TWL) was 30.5% at 4 years of follow-up (32.3% in primary and 28.3% in revisions). Six intra-operative (2%) and 28 postoperative complications (9.3%) were seen. Out of this 28 complications, 11 (3.6%) were late complications. Reoperations were performed in 15 patients (5.0%). Clinically relevant EBAR was present in 3 cases only (1%) 4 years after the operation.

Conclusions The LPRYGB combines the main advantages of the OAGB (light restriction and moderate malabsorption) with the anti-reflux effect from the Roux-en-Y diversion.

Keywords Long pouch gastric bypass · LPGB · Morbid obesity · Biliary reflux · Hypoglycaemia · Roux-en-Y diversion · Entero bilioacid reflux · EBAR

Background

In Roux-en-Y gastric bypass (RYGB), intermediate and long-term weight regain raises some concerns. Christou et al. [1] demonstrated both morbidly obese (20.4%) and superobese (34.9%) patients with RYGB experienced significant weight regain from the nadir to 5 years and again from 5 to 10 years. Other authors have better durability of weight loss. Adams [2] reported a 26.9% total weight loss (TWL) and a 51% remission rate of type 2 diabetes (T2DM) 12 years after surgery. According to the SOS Study, recurrence of T2DM occurs also in 50% of the initial successful remission cases 10 years after RYGB [3]. Hyperinsulinemic hypoglycaemia is also a disturbing consequence in up to 8% of the patients [4].

The one anastomosis gastric bypass (OAGB) is growing fast in popularity as a simple, safe and effective procedure compared with (RYGB) [5]. It seems to have better results in terms of weight loss and diabetes control in the long run [6].

In 2010, we began to perform OAGB and we experienced a reduction in the early and late morbidity, number of weight regain cases and absence of hyperinsulinemic hypoglycaemic episodes.

There is controversy about the incidence of "biliary reflux", after OAGB [7]. Different publications report enterobilio acid reflux (EBAR) in low rates (2–4%) [8–10] But, in case of revision procedures, rates are higher, mainly in failed band revisions [11, 12].

In our first 200 OAGB cases, 44% of them for failed band or sleeve, the most significant complication we had to face

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was EBAR (4%), which we decided to revise. Technically, we performed a Roux-en-Y diversion with the "double loop technique" [13] cutting the afferent loop before the gastro-ileostomy and creating a new side-to-side enteroenterostomy 100 cm far from the GE in the previous efferent limb achieving the same low-weight and good comorbidities control.

Subsequently, we decided to add this step in secondary OAGB operations to prevent future reflux mainly in patients with previous band, sleeve with GERD. We performed this as a primary operation in patients with hiatus hernia larger than 3 cm or with symptomatic GERD. We call this variation "Long Pouch Roux-en Y Gastric Bypass" (LPRYGB). The main differences between the three bypass versions are shown in Fig. 1.

Important differences compared with regular RYGB are longer gastric pouch (> 16 cm), larger anastomosis (3 cm) and a longer biliopancreatic limb (200 cm). Comparing with RYGB, these patients clearly have less restriction (large anastomosis) and some steatorrhea because of fat hypo-absorption. Here we report the outcomes of our LPRYGB cases with 4 years of follow-up.

Methods

We retrospectively analysed our prospectively collected data on 389 LPRYGB cases performed from 2013 until August 2018. Average follow-up time was 24.4 months and 61 patients with less than 6 months follow-up were excluded; 28 patients (7.2%) were lost for follow-up; in the remaining cases, missing data were completed by case note reviews and phone calls.

Every patient was fully informed about the clinical profile, expected outcomes and risks of this procedure and signed a specific informed consent. The institutional "review board" approved the study, verified the compliance with ethical standards. Basic descriptive statistics were used.

Preoperative Course

All patients had a multidisciplinary approach following the national Portuguese guidelines [14, 15] to the preoperative and postoperative period. An endocrinologist, psychologist, nutritionist, psychiatrist, the anaesthesiologist and the surgeon made the preoperative assessment. All the patients were submitted to a regular evaluation with complementary diagnostic tests including an endoscopy with oesophageal mucosa biopsy whenever an esophagitis was diagnosed. The revision cases had also a radiologic assessment with upper gastrointestinal series or CT scan. Gastro-oesophageal reflux (GERD) was considered to be present based on the symptoms, endoscopic, pathologic or radiologic findings.

All patients had low calorie preoperative regimen (1000 Kcal/day) for a minimum of 7 days.

Surgical Technique

Figure 1 shows a comparison between RYGB, OAGB and LPRYGB. Important remarks based on already described LPGB technique [16] are as follows:

- Angle of His is dissected and hiatal hernias bigger than 3 cm are repaired usually with a posterior cruroplasty. "Incisura angularis" dissection is performed at the level or below the "crows foot". A long and slim gastric pouch is constructed with endostaplers over a 36 French bougie.
- Like in OAGB, we select a first spot 200 cm from the Treitz angle for the gastroenterostomy defining the length of the future biliopancreatic limb. This length is tailored accordingly to the patient characteristics. In superobese or diabetic people, we increase it by 50 cm (250 cm). In older people (above 60 years), BMI under 40 Kg/m^2 or vegetarians, we reduce it by 50 cm (150 cm).
- Then, we measure 1 m of bowel distally to be the alimentary limb, defining a spot, plus more 3 m for the common channel. If we do not have those further 4 m (shorter

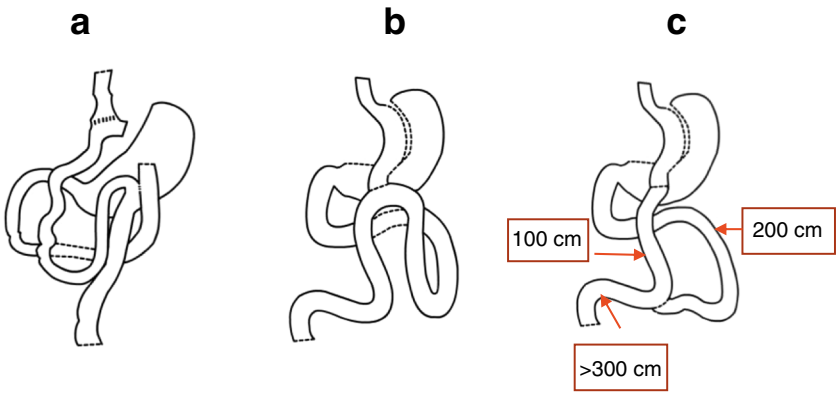

Fig. 1 Technique comparison between **a** Roux-en-Y gastric bypass (RYGB), **b** one anastomosis (OAGB) and **c** long pouch Roux-en-Y gastric bypass (LPRYGB)

bowel), we reduce the length of the BP limb in order to achieve those lengths.
- We strive to measure the entire bowel but, in case of a short mesentery or heavy bowel, as soon as we are able to get the referred measurements (1 + 3 m) we stop to count further to avoid iatrogenic injury.
- After those measurements, at the first spot, a gastroenterostomy (GE) is made on the anterior surface of the gastric pouch, with a white 30-mm stapler magazine. The enterotomy is closed with Vicryl 2/0, continuous suture.
- A side to side entero-enterostomy (EE) with a 60-mm white stapler cartridge is performed between a second spot 1 m distal to the GE and the BP limb immediately before the GE, defining the alimentary limb length (1 m).
- After a methylene blue test to the GE, dividing the bowel between the two anastomosis with a 60-mm white cartridge does maturation of the Roux-en-Y diversion.
- The intermesenteric and the Petersen space are closed with a purse string 2/0 silk. Application of a spray of fibrin glue on the staple lines and anastomosis is usually done. The drainage of the abdominal cavity is selectively used. Nasogastric tubes or urinary catheters are not used routinely. The port sites with a diameter bigger than 10 mm are closed with transparietal non-resorbable stitches.

Postoperative Course

Patients are mobilized at 6 h, allowed liquids 12 h postoperatively and discharged on the second postoperative day. Enoxaparin is prescribed (40 to 100 mg a day) for 7 days, ursodeoxycholic acid (250 mg 2 or 3 times a day) for 3 months and pantoprazole (40 mg a day) for 6 months. This extended use of proton pump inhibitors is due to the longer pouch than that used in the LPRYGB. In a recent study by Edholm et al. [17] it was shown that the relative risk of marginal ulcer formation increased with 14% with each centimetre of stapler used for the pouch. The protocol includes supplementation with multivitamins (Fitforme® or Bariatric Inspire®) plus high-dose cholecalciferol pills (22,400 UI each 2 weeks).

The protocol includes observations every 3 months during the first year, every 6 months in the second and then, once a year. Laboratorial evaluation is done at 1, 6 and 12 months in the first year and then once a year. Once a year, we check for the *Helicobacter pylori* presence (and eradication if positive in the urea breath test) and ask for an abdominal ultrasound test to detect biliary stones and steatosis evolution. In order to evaluate possible esophagitis, gastritis or marginal ulcer, a barium swallow and an upper GI endoscopy are requested at the end of the first postoperative year. Further endoscopic evaluations are asked after 2 and 5 years or whenever the patient complains are suggestive of reflux, obstructive or ulcerative disease.

Definitions for Remission of Comorbidities

T2DM Remission of T2DM was defined as a HbA1C level < 6%. Amelioration was patient was able to reduce the antidiabetic medications or able to get off some of the antidiabetics (e.g. insulin).

Hypertension Amelioration is reduction in dosage of antihypertensive medication or stopping of some of the medications. Cure was defined when all antihypertensive medications were stopped.

Dyslipidaemia Amelioration is reduction in dosage of lipid-lowering medication or stopping of some of the medications or improved blood levels of either HDL cholesterol (increase) or a decrease of LDL cholesterol. Cure was defined when all lipid-lowering medication were stopped.

Osteoarthritis/Degenerative Joint Disease Amelioration is a reduction of complaints or reduction of medication.

Obstructive Sleep Apnoea (OSA) Amelioration is defined as a lowering of the Apnoea–Hypopnoea Index (AHI) or reduction of symptoms. Cure was defined as cessation of C-PAP.

Gastro-Esophageal Reflux Disease (GERD) Amelioration is defined as reduction of symptoms or cessation/reduction of medication (like proton-pomp inhibitors (PPIs)).

Results

We analysed the outcomes of 300 operated cases of LPRYGB, 169 primary and 131 revision cases. The recorded perioperative data are presented in Table 1.

Table 1 Perioperative institutional data (basic demographics)

Variable	LPRYGB
Women (n)	243 (81%)
Age (years)	45.8 (16–70)
BMI (Kg/m^2)	41.3 (27,8-56,9)
Mean operative time (min)	65 (45–195)
Conversion rate	0
Average hospital stay (days)	3.2 (1–23)
Early readmission rate	10 (3.3%)
Late readmission rate	8 (2.7%)
Mean Follow-up (months)	24.4 (6–48)

In order to get a 3-m common limb, intra-operatively, we had to shorten the BP limb four times. The average BP limb in all the 300 cases was 217.6 cm.

The total morbidity rate was 9.3% (5.6% early and 3.6% late events). The total morbidity in primary cases was 8.9% in revisions was 9.6% (Table 2).

Out of 17 (5.6%) cases of early complications, 10 (3.3%) were Clavien Dindo grade IIIb (with reoperations), 5 after primary and 5 after revision cases. The other 7 cases were grade I or II. No grade IV (life-threatening complications) occurred.

The weight evolution of the 300 cases was from 111.2 Kg (BMI 41.3 Kg/m^2) in the preoperative time to 76.9 Kg (BMI 29.6 Kg/m^2) 48 months after the surgery. The percentage total weight loss (%TWL) was 30.5% at 4 years of follow-up (Fig. 2), 32.3% in primary cases and 28.3% in revision ones. For the revisional cases, the weight before the revision operation was used for calculation of TWL.

The re-operative rate was 5.0% (2.7% in primary and 2.3% in revisions) (Table 2).

Marginal ulcers were diagnosed in 3 patients. One (penetration to abdominal anterior wall) needed reoperation (gastroileostomy reconstruction). The remaining 2 cases were successfully dealt with medical management. One revision patient presented 3 months after the operation with steatorrhoea, anaemia and hypoproteinemia. He was managed with protein intake reinforcement plus pancreatic enzyme and probiotics with good result.

EBAR was seen in 3 patients (1.0%), two of them successfully treated with surgery. Both were submitted to recurrent hiatus hernia repair (posterior cruroplasty), one with mesh repair, and the other with a Toupet-like fundoplication with the gastric remnant. One case is under medical treatment with satisfactory result. No "de novo" cases were found.

There were no cases of hyperinsulinemic hypoglycaemia or significant anaemia. We performed 2 cholecystectomies in cases of symptomatic gallstone disease. Mortality was 0%.

Table 2 Overview of the early and late postoperative complications after long pouch Roux-en-Y gastric bypass (LPRYGB)

Postoperative complications						
	EARLY					
	Global ($n = 300$)		Primary ($n = 169$)		Revisional ($n = 131$)	
	n	Reops	*n*	Reops	*n*	Reops
Hemoperitoneum	2	2	2	2	–	–
Intra-abdominal infection	2	2	1	1	1	1
Pouch leak (His angle)	1	1	–	–	1	1
Ileo-ileal anastomosis leak	1	1	–	–	1	1
Bowel perforation	1	1	1	1	–	–
Wound infection	3	–	2	–	1	–
Abdominal wall hematoma	2	1	1	1	1	–
Port site hernia	3	2	1	–	2	2
Haematochezia	1	–	1	–	–	–
Pleural effusion	1	–	1	–	–	–
Total	17 (5.6%)	10 (3.3%)	10 (5.9%)	5 (3.0%)	7 (5.3%)	5 (3.8%)
	LATE					
	Global ($n = 300$)		Primary ($n = 169$)		Revisional ($n = 131$)	
	n	Reops	*n*	Reops	*n*	Reops
Alimentary intolerance	3	2	1	–	2	2
EBAR	3	2	2	2	1	–
Marginal ulcer	3	1	2	1	1	–
Steatorrhea	1	–	–	–	1	–
Port site hernia	1	–	–	–	1	–
Total	11 (3.6%)	5 (1.6%)	5 (3.0%)	3 (1.8%)	6 (4.6%)	2 (1.5%)
Total morbidity	*28 (9.3%)*	*15 (5.0%)*	*15 (8.9%)*	*8 (5.6%)*	*13 (9.6%)*	*7 (5.3%)*

Clavien-Dindo: Grade I: 3 cases; Grade II: 4 cases; Grade III: 10 cases; Grade IV: 0; Grade V: 0

;*EBAR*, entero bilioacid reflux; *Reops*, reoperations

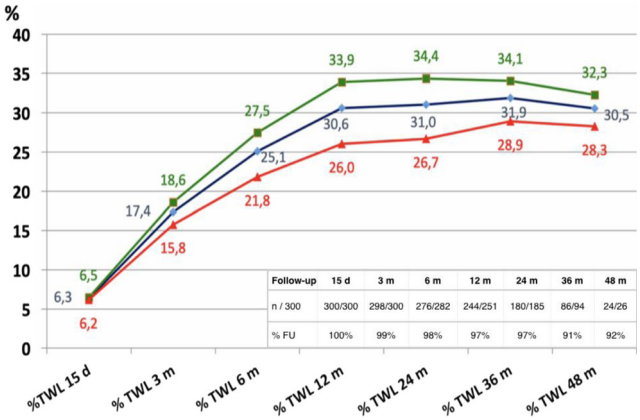

Fig. 2 Percentage total weight loss (%TWL) in both primary and revision procedures plus follow-up rates at each time point. The blue line shows the total rates of the procedure. The green line shows the rates of primary long pouch Roux-en-Y gastric bypass (LPRYGB). The red line shows the rates of revisional long pouch Roux-en-Y gastric bypass (LPRYGB). The asterisk indicates that for revision procedures, the weight before the revision operation was used for calculation of TWL

The main nutritional deficiencies were iron (13.7%), Vitamin D 25OH (11.7%), folate (3.0%) and Vitamin B12 (2.7%). Hair loss was seen in 8.0% of the cases and chronic diarrhoea in 1.3%. Hypoproteinemia was present in only 3.3% of the cohort.

The comorbidity improvement was in line with the OAGB, improvement in 82.2% of the type 2 diabetic patients and 70% of the ones with high blood pressure (Table 3).

Table 4 gives the indications for revisional surgery after either gastric band or sleeve gastrectomy. The majority of the failed gastric bands or sleeve gastrectomies were because of weight regain. In case of GERD, the symptoms were confirmed by esophagogastroduodenoscopy and hence, revision was offered.

Discussion

The surgeons performing OAGB are claiming better outcomes and fewer complications compared with RYGB [7, 18–21]. Biliary reflux or EBAR is a debated topic, even if the incidence reported is low [6, 11, 12, 22]. This is because most of the cases are refractory to medical treatment [23, 24] and some patients, facing the disturbing clinical complaints, may require surgical treatment. In our initial practice with OAGB, we had 4% of EBAR after 200 and 2.6% after 650 cases [25]. By adding a Roux-en-Y diversion to those primary OAGB, the EBAR incidence decreased to 1% [25].

There is still a lot of discussion about the relation between biliary reflux after OAGB and risk of gastric stump cancer [26]. EBAR carrying bile into the stomach is a common finding in upper GI endoscopies, and many authors discuss the generally accepted relation between bile presence and gastric cancer [27, 28]. The presence of bile in the oesophagus is clearly related with the occurrence of Barrett's epithelium. The presence of duodenal enzymes leads to oesophageal epithelial destruction in animal [14] and humans [15] and promotes the risk for cancer.

The technique we are proposing here avoids biliary reflux and gastric mucosa and oesophagus bile wash, so the technique avoids these potential risks to patients.

But EBAR may be a late complication even after RYGB [16]. The reason for this may be the anatomical or functional shortness of the alimentary limb. A similar process may occur in LPRYGB. When we revised three cases of oesophageal reflux with EBAR, two of them presented short alimentary limbs (50 and 60 cm), probably from wrong measurements, which we elongated. Since then, after 50 cases, we increased the alimentary limb up to 100 cm. All 3 cases with EBAR had previous hiatal hernias (one of them big) and in the 2

Table 4 Indications for revisional surgery (*N*)

	Band (*n*)	Sleeve (*n*)	Total (*N*)
Weight regain	80	14	94
GERD	3	4	7
GERD + weight regain	21	9	30
Total (*N*)	104	27	131

GERD gastro-oesophageal reflux disease

Table 3 Comorbidities and amelioration rates

Comorbidity	Preoperative status	% amelioration	% off treatments
T2DM	84 (28%)	80.2%	54%
Hypertension	139 (46.3%)	70%	44%
Dyslipidaemia	124 (41.3%)	54%	42%
OSA	81 (27%)	67%	63%*
Degenerative joint disease	126 (42%)	55%	49%
GERD	141 (47.7%)	91%	86%

*off CPAP

T2DM type 2 diabetes mellitus, *OSA* obstructive sleep apnoea, *GERD* gastro-oesophageal reflux disease

reoperated cases, both hernias were recurrent and treated again with good symptomatic control.

Björklund concluded that the gastric pouch and the Roux limb behave as a common cavity during food ingestion and have the same intraluminal pressure [25]. The pressure does not correlate to weight loss nor to the meal size or rate of eating. Also, it is not clear if this status lasts out of the alimentary bolus passage time. But if this shared pressure stands, the EBAR fluid may progress backwards from the entero-enterostomy up to the lower oesophageal sphincter [18] and may induce oesophageal mucosa inflammation or even erosion.

In consequence, each surgeon must keep these issues in mind and try to detect and treat the EBAR conservatively (alimentary behaviour change, cholestyramine and prokinetics). If he does not succeed, check for any anatomical hiatal defect and propose the patient a surgical repair. Alimentary limb elongation, cruroplasty, Hill-type gastropexy, or partial fundoplication using the gastric remnant or even a Belsey-Mark IV procedure are possible solutions [19]. Endoscopic procedures and techniques (Stretta®, LINX®) may become valuable in the near future, as new devices are now available with interesting outcomes [20, 21, 29].

Another important issue is the gastric pouch length and width. It is consensual that the pouch must be long and slim to avoid future dilation and bile reflux [11]. If a very narrow tube is more prone to anatomic or functional stenosis (torsion or dysmotility), larger pouches may lead to excessive acid production and pure acid GERD [30]. Our suggestion is to perform a long pouch calibrated on 36 French bougie avoiding any rotational mechanism or stricture.

In another view, if a long and slim pouch helps to avoid oesophageal mucosa EBAR exposition, a longer pouch may also induce more acidity that, at least theoretically, may lead to an increased risk of marginal ulcer. By now, in our data, we have not seen such an effect but we need to check in future re-evaluations of this cohort and longer follow-up data will provide these details.

Ideally, the bowel length must always be measured. There is now enough evidence showing that a long BP limb provides more weight loss and better metabolic effect [31–36]. In LPRYGB, the common channel is usually 200 cm and the alimentary limb 100 cm. The common channel length must be about 300 cm or more to avoid malnutrition. When measuring the bowel, if 300 cm are not affordable for the common channel, we reduce the BP limb length as much as necessary to get at least this common channel safe length.

Our experience shows that LPRYGB is a good strategic option for patients exposed to EBAR presence or potential risk and seems to be an effective and safe approach in primary and revision cases. It allows very safe surgery, excellent weight loss and comorbidity control, even though we need longer follow-up and further prospective comparative studies to certify these apparent advantages.

Conclusion

The LPRYGB combines the main advantages of the OAGB (reduced restriction and moderate fat malabsorption) with the anti-reflux effect of the Roux-en-Y diversion. It is a safe and technically reproducible procedure. The weight loss and the comorbidity control at 48 months are comparable to literature OAGB published data.

Our outcomes confirm a low rate of enterobilio acid reflux as RYGB. It is also much convenient and effective as a salvage technique in cases of failed restrictive surgery, usually weight regain, reflux or both together.

Compliance with Ethical Standards

Conflict of Interest The authors declare that they have no conflict of interest.

Ethical Approval Statement An institutional review board approved this study.

Informed Consent Statement Does not apply.

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