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Research Article

Limbs Length, Gastric Pouch Size and Gastro-Jejunal Anastomosis Diameter in Roux-en-Y Gastric Bypass-What is the Optimal Configuration?

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Abstract

Background: The sizes of the gastric pouch, alimentary limb or bilio-pancreatic limb in Roux-en-Y Gastric Bypass (RYGB) are not standardized and the length of the limbs can vary largely from one surgical team to another.

Materials and Methods: We performed a literature research to study the optimal limb lengths, the right gastric pouch size and the gastro-jejunal anastomosis diameter in RYGB and their correlation with the dynamics of weight loss and comorbidities control.

Results and Discussions: The review found that an Alimentary Limb (AL) of 150-200 cm and a bilio-pancreatic limb (BPL) between the 100-150cm had a positive impact on the weight loss. A BPL > 150cm can provide more benefit in term of weight loss especially for the patients with BMI >50 kg/m2. In term of comorbidities reduction, we found that an BPL of 200 cm, an AL of 150cm and a common Limb (CL) of 200 cm have a positive impact. To minimize the nutritional deficiencies, an CL of at least 100cm - 150cm, a BPL of 150 cm and an AL 150cm or an AL+CL of 400cm - 450cm are indicated. For the gastric pouch, we found that a volume of 25ml-30ml and a diameter of the gastro-jejunal anastomosis of 2.5cm-3cm are recommended.

Conclusion: The optimal limb lengths provide the best weight loss and comorbidities reduction and a low impact on nutritional aspect. A gastric pouch and gastro-jejunal anastomosis correctly fashioned will provide a good restriction mechanism and will prevent the dumping syndrome and local symptomatology.

Keywords: Bariatric surgery; Gastric pouch; Limb length; Roux-En-Y gastric bypass

Background

Bariatric surgery is an efficient treatment option leading to sustainable weight loss and reduction in comorbidities in morbidly obese patients. Laparoscopic gastric bypass is regarded as the gold standard treatment of the obesity, but this procedure is challenged by other procedures such as sleeve gastrectomy or single anastomosis gastric bypass.

Up to now, there is no clear consensus on the size of the Gastric Pouch (GP), Alimentary Limb (AL), Bilio-Pancreatic Limb (BPL) or Common Limb (CL) in Roux-en-Y Gastric Bypass (RYGB). The length of the limbs can vary up to 100cm-150cm from one surgeon to another and there are neither guidelines nor a consensus after a comparative study on more than 10 years in literature. The debate is still concerning the optimal measures of the limbs and the size of the gastric pouch and the consequences on weight reduction, onco-morbidities control and the Quality of Life improvement (QoL). We performed a review of literature looking for the optimal limb lengths in gastric bypass, the gastric pouch size and its correlation the quality of life improvement, with the Body Mass Index (BMI), and comorbidities dynamics.

Materials and Methods

PubMed, Google Scholar, MEDLINE and Cochrane databases were researched. We search for clinical studies, meta-analysis, reviews, and case reports. The search terms included bariatric surgery, Roux-en-Y Gastric Bypass, Gastric Bypass limb

length and Distal Gastric Bypass, Gastric Pouch Size. The articles were included if they described the length of the limb in gastric bypass, revisional bariatric surgery, relations between limbs length and the weight loss, follow up post gastric bypass, comorbidities and QoL. The studies that described variations from the standard technique of RYGB and those with a follow up less than 6 months were not including. The studies were selected and classified according to the subject of discussion.

Results and Discussions

The gastric bypass technique was reported at the first time in 1967 in an incipient shape and size, but over the years, many technical modifications were performed [1]. The description in classical RYGB of AL's length was between 100 and 150 cm and between50 and 75 cm for the BPL. The CL length was not defined because the fact of the measurement is not performed systematically [2]. The reported lengths in publications of AL and BPL are widely from 10-250 cm to 35-250 cm, respectively [3].

Physio-Pathological and Functional Mechanism

Most of the jejunum is by-passed and the upper anastomosis is a gastro-ileal anastomosis in gastric bypass with a very long BPL. In a prospective study of 187patients who underwent RYGB, found that on an AL of 200 cm, the hormonal and immunological mechanism were altered, and could lead to modification of eating behavior with patient's loss of appetite. An ALof 200-cm gives a better weight loss than on AL of 150-cm, but had more nutritional deficiency [4]. RYGB has a direct effect on glucose homeostasis through hormonal mechanisms. The duodenal exclusion from the alimentary circuit inhibits the production of anti-incretin factor ameliorating the blood's sugar level in diabetes. A longer BPL could modify the hormonal profile with better glycemic control. The decrease of the glucose level can lead to lower absorption of fat and lower levels of free fatty acids in the portal circulation improving insulin function [5]. RYGB with a longer BPL results in a distinctive postprandial hormone profile with augmented glucagon-like peptide-1(GLP-1) and neurotensin responses with beneficial metabolic outcomes of the surgery [6]. After RYGB, ghrelin, a hormone that stimulate the appetite, levels are post-prandially reduced who can influence the successful weight loss. Also, the Peptide YY (PYY) who regulates satiety can present an increase level postprandial. Reactive hypoglycemia on contrary can be a source of weight regain [7].Both the roles of ghrelin and Peptide YY (PYY) need further clarifications to define the role in long-term weight regain [8].

The Weight Loss Correlations

Some authors found no influence on weight loss of the limb length but for others the long limb can be a real advantage and provide an effective weight loss. A group of studies evaluate the effect of different limb lengths in RYGB found no differences in term of weight loss on the patients studied. In a prospective randomized study on RYGBP in 90 patients found no evidence that the anatomical variations of common limb could influence weight loss [9]. Had the same point of view in a retrospective study on 274 the patients who underwent RYBG with a mean of 11.4 years of follow up found also no difference in results between the long- and short-limb operations in term of weight loss [10]. A retrospective study was performed by 89 patients who underwent RYGB, among them 46 patient's regular limb length (BPL 60 cm and AL 100 cm) and 43 long limb length (BPL 150cm and AL 100 cm). The results of this studies show that long BPL RYGB provide no significant results than regular BPL RYGB in term of weight loss [11]. In a review of literature found that AL length have no significant role in the weight loss for patients with BMI <50 kg/m^2. A longer BPL (> 150 cm) may be associated with a modest weight loss advantage for BMI>50 kg/m^2 and has no significant impact on patients with BMI ≤50 kg/m^2 [12]. in a study on 120 patients different lengths of the BPL and AL (AL 50cm vs 100 cm BPL, AL 150cm vs BPL 200 cm, AL 100cm vs BPL 150 cm, AL 50cm vs BPL 100 cm) found that the different lengths did not affect the percentage of total weight loss [13].

Jose S. Pinheiro in retrospective study on 105 patients with a body mass index of >50 kg/m^{2}found that a long BPL, AL and a short length of the CL affects the weight loss. Longer BPL could leads to more weight loss not through malnutrition but through distal delivery of nutrients and more stimulation of incretins, higher levels of systemic bile acids [14]. In a prospective randomized study on 120 patients with BMI 50 kg/m^2 who had either standard limb length (BPL 50-80 cm, AL 120-150 cm) or long limb length (BPL50-80 cm, AL 170-200cm) gastric bypass found that the long-limb gastric bypass have better weight loss outcomes in patients with super-obesity (BMI >50 kg/m^2) than the standard limb length [15]. In a retrospective systematic study over 2.5 years on patients with a BMI < 50 kg/m^2 who underwent primary laparoscopic RYGB with 1 year follow up reported that by increasing the length of BPL in RYGB increases Excess Weight Loss (EWL) in patients with super obesity (BMI >50 kg/m^2). The same results with a long limb length were obtained for the patients with a BMI < 50 kg/m^2 [16,17]. ELEGANCE REDO trial on 146 patients, who underwent RYGB randomized in 2 groups with 73 patients AL/BPL 150/75 cm, and 73 patients AL/BPL 75/150 RYGB found that a long BPL and short AL can results in more weight loss [18]. 115 patients in a study on 56 and 57 patients in the proximal group 150 cm AL and distal group (150 cm CL) increasing the BPL and decreasing the CL, improve the weight loss [19]. Distalization, by increasing the BPL length and decreasing the CC length can improve the weight loss [20]. In a review on 799 studies about revision RYGB for weight regain found that the configuration AL 100-150 cm, and CC at 150 cm was associated with excellent weight loss but with highest potential nutritional deficiencies [21]. In a systematic

review concludes that a range of 100-200 cm for AL+BPL gives optimal weight loss with RYGB in most patients. AL+BPL> 200cm may be better in patients with super obesity if total small bowel length may have > 300 cm [22].

In a prospective randomized study over 5 years compared 3 groups of patients with different lengths of alimentary limb: 41-61cm; 130-160-cm and 115-250-cm. Longer AL seems better early and late weight loss in patient with BMI<50kg/m^2. Orci L [17] in a systematic review suggests that a longer AL might be efficient in improving postoperative weight loss especially in patients with super-obesity (BMI>50 kg/m^2) [23]. State that AL of 50 cm limit the effectiveness of RYGB and AL of 100 cm do not necessarily achieve better weight loss in patients with BMI < 50 kg/m^2. Patients with BMI > 50 kg/m^2 could benefit from AL between 130 and 150 cm and might not be greater benefit with longer AL [24,25]. In another review on 174 studies concerning the failure in revisional bariatric surgery found that in patients with super obesity CL length is more important than AL or BPL length in weight loss due to malabsorption at this level [26].

Those studies present a wide range of results and lengths with convincing results for each one with many contradictions so it is difficult to conclude and to recommend the best length in order obtain the best postoperative results. The long AL of 100-150cm and BPL of 150cm-200cm can provide a significant advantage on the weight loss to patients with super obesity (BMI>50 kg/m^2) and with many comorbidities. In any case is sure that CL length plays a very important role in the processes of weight loss independently of AL or BPL length. A short CL provides an important weight loss but with the price of nutritional problems (Table 1).

Study	Nr Patients	AL (cm)	BPL (cm)	CL (CM)	WL
Nergaad, et al.	187	200	0	0	1
Pinherio, et al.	105	250	100	0	1
Sarhan, et al.	120	170-200	50-80	0	1
Gleysteen, et al.	344	115-250	0	0	1
Van der Burgh, et al.	47	250-300	75	0	1
Boerboom, et al.	146	75	150	0	1
Stefanidis, et al.	review	0	>150	0	1
Tran, et al.	review	150	0	150	1
Shah, et al.	671	150	200	0	1

Table 1: Influence of the limb length on the weight loss.

The Gastric Pouch Size

The size of the gastric pouch is an important element for the good outcome of the RYGB. There is no consensus in the size of the gastric pouch and the Gastro-jejunal Anastomosis (GJA). Both are responsible of the restriction mechanism. In a study on 380 patients, defined the anastomosis with a diameter of 2 cm as normal and the pouch was considered enlarged if 6 cm long or 5 cm wide [27]. The size of the pouch is a very important in RYGB dynamics. If it is small (15-20 mL) and if size of the anastomosis is more than 2.5 cm, the gastric draining is faster and can increase the dumping syndrome. If the pouch size is big (> 30ml) and the size of the anastomosis is more than 2cm, it can cause a retrosternal discomfort, gastro-esophageal reflux, marginal ulcer oran anastomotic stenosis [28]. In a meta-analysis, recommend a pouch size of 30 mL and the size of the gastro-jejunal anastomosis diameter of 2.5cm. [29]. In a prospective study on 76 patients with10-20 ml pouch and 25-35 ml pouch size in RYGB found a greater efficiency on weight loss and glycemic control with smaller pouch size compared to larger pouch size [30].

On contrary Riccioppo D in a retrospective study 67 patients suggest that a small pouch with rapid emptying rate is an important technical parameter in weight loss, but a dumping syndrome can occur. Smaller pouch size was associated with a faster gastric emptying, greater weight loss maintenance, and better food tolerance [31]. Edholsom in a study on 14,168 patients [32]. In a study on 10 patients found that a faster pouch emptying rate was associated with poor weight loss [2]. Uittenbogaart in a radiological contrast study on 200 patients showed that there was 23% pouch dilatation in patients with weight loss failure after RYGB [33]. In reintervention after RYGB, the reshaping of the gastric pouch, can lead to adequate weight loss [34,35]. There are no much contradictions in the studies about the gastric pouch and GJA diameter. The gastric pouch of 20-30ml and a GJL of 2-2.5cm seem to give the best postoperative results in term of restriction mechanism, dumping syndrome with no discomfort, and has a lower impact on the prevalence of marginal GJL ulcer (Table 2).

Study	Nr Patients	Gastric pouch size (cm)	Gastric pouch Volume (ml)	GJA Diameter (cm)	WL	Diabetes	Accelerated rate of the pouch emtyping
Ugale, et al.	review	0	2.5	30	1	0	0
Heneghan, et al.	380	<6/5	2	0	1	0	0
Riccioppo D, et al.	67	0	0	<15	1	0	0
Deden, et al.	10	0	0	<15	0	0	1
Ren, et al.	76	0	0	25-30	0	1	0

Table 2: Influence of the gastric pouch and the gastro-jejunal anastomosis size on the weight loss, diabetes reduction and rate and pouch emptying.

Comorbidities Control

The reduction of comorbidities is among the indications of bariatric surgery. There was no influence of the AL and BPL lengths on the comorbidities reduction. In a retrospective study on 20 patients found no influence of the length on the metabolic syndrome [36]. GATEWAY TRIAL evaluates the efficacy of RYGB and had the same conclusion [37,38]. Other studies found the correlation between the limb length and the comorbidities control. In a retrospective review on 96 patients an improvement of weight loss and resolution of comorbidities in case of a total alimentary limb length (AL+CL) of 400-450 cm [39]. The majoration of the BPL gives significantly higher weight loss and lesser weight regain with a better resolution of obesity-associated comorbidities [40]. Shin in a retrospective study on 22 patients showed that a CC length of 200 cm may be favorable in achieving weight loss with a decrease of comorbidities [41]. Retrospective study on 47 patients who underwent a conversion from 100cm-150cm AL and 75cm BPL to 250cm- 300cm AL and remaining length of BPL showed that the distalisation improves weight loss and co-morbidities. A longer CL of 200-300cm might be a better option to reduce malnutrition and diarrhea [42].

About the diabetes mellitus; Pal in a study on rats found that BPL length modulates multiple antidiabetic mechanisms specifically their dose-response. A longer BP limb reduces glucose absorption. This reduction may prevent weight regain and diabetes relapse. According to this study, BPL should be personalized to the patient and desired metabolic effect [43]. In a study on 20 patients found that 11 patients with 200 cm BPL and 9 patients with BPL of 60-100 cm suggest that a longer BPL does not have a negative impact on nutrient absorption and seems to have a positive influence post-prandial acetate levels with positive metabolic effects. [44]. In a retrospective study on 58 patients with obesity, Type 2 Diabetes Mellitus (T2DM), and hyperlipidemia, 31 patient with BPL of 160 cm to 200cm and 27 patients with BPL of 210cm to 240cm found a significant positive effects on weight loss and T2DM control in the long BPL length group [45]. In a retrospective study on 114 patients with RYGB, (41 patients with BPL 84±2cm and 73 patients BPL 200cm) found that the long BPL improves percentage of excess BMI loss, diabetes remission, and glycemic control in those with persistent disease, while it decreases diabetes relapse rate over time. The results of the study suggest that long BPL RYGB can be more adapted for the diabetic patients [46]. In a prospective study on 93 patients found that 51 patients with BPL 50 cm- 75cm and 42 patients with BPL 100-150 cm with T2D Msustain that a longer BPL can intensify the anti-diabetic effect and the CL influences the medium-term of diabetes remission [47,48]. In a prospective study on 25 patients with T2DM and a fasting C-peptide more than 1 ng/ml who underwent laparoscopic RYBG found that a CL<600 cm had a statistically significant improvement in T2DM compared to CL>600cm [49]. In a retrospective study on 102 patients with BMI 30-35 kg/m^2 who underwent RYGB with BPL of 200 cm and AL of 50 cm found that this length is safe and seems effective in achieving good control of T2DM in patients [50]. Total of 28 patients received revisional surgery conversion found that additional weight loss is acquired from adding 100-150 cm to a 50-75 cm BPL, intensifies the antidiabetic effect in a RYGB, but increased risk of protein deficiency with subsequent malnutrition [51].

The variations in the limb lengths have more influence on the T2DM, and most of the studies support this aspect. The data collected from the studies reveals that a 150cm- 200 cm BPL length have a good effect, and should be fashioned longer if the patient presents T2DM. A total size of AL+CL of 400-450 cm has also a positive impact on the comorbidities reduction. Also, a CC length more than 200cm have a good effect on the comorbidities but limits the nutritional problems (Table 3).

Study	No. of patients	AL (cm)	BPL (cm)	CL (cm)	Nutritional Problems	Impact on Diabetes	Other Comorbidities
Nora, et al.	114	0	200	0	0	1	0
Kaska, et al.	93	0	150	0	0	1	0
Ramraj V, et al.	25	0	0	<600	0	1	0
Kraljevic, et al.	28		150-225	0	1	1	0
Jarak, et al.	20	0	200	0	0	0	1
Schiavon, et al.	45	150	100	466±86.4	0	0	1
Shin, et al.	22	0	0	200	1	0	1
Ghinassi, et al.	96	0	0	AL+CL=400-450	0	0	1
Murad, et al.	120	50	200	0	0	1	0
Yan, et al.	58	0	210-240	0	0	1	1

Table 3: Influence of the limb length size on the comorbidities reduction.

The Side Effects of a Longer Limb

Not all the studies support the idea that longer AL or BPL limb have a negative with BPL varied from 100 cm to 150 cm found a no correlation between BPL and changes in nutrient levels [52,53]. In a prospective study on 250 patients who compare the effect of a BPL of 70cm vs 120cm with constant AL of 150 cm failed to demonstrate significant differences in weight loss and remission of comorbidities greater deficiencies of vitamin B12, vitamin A, and folic acid. The difference of length in not very important, so the results of this study are not surprising [54]. There is also a lesson to learn from the experience of One-Anastomosis Gastric Bypass (OAGB). In a study on OAGB found that BPL of 150-250cm does not cause severe nutritional deficiencies [55]. At the opposite other authors found an important negative of a long BPL limb on the nutritional deficiencies. BPL> 200cm shown an improvement in co-morbidities, like remission of T2DM but the patients could be present a higher incidence of food intolerance (82%), watery stools (71%) and 16% renal stones [56]. Chen in a retrospective study on 2397 patients evaluated the serum albumin and total protein before and one year after surgery. For metabolic surgery a long BPL is recommended. Protein deficiencies might be more important if the CL measures less than 400 cm [57].

The CL is very important for the evolution of nutritional problems. AL+CL between 400 and 450 cm demonstrated a lower incidence of nutritional issues, with negative effect on calcium, on parathyroid hormone, and the fat soluble vitamins A and D [39]. In a prospective study on 151 patients conclude that the CL has no effect on weight loss in RYGB patients but a short CL is related to greater nutritional deficiencies [58]. In a retrospective study on 29 patients with conversion from a 150-cm BPL to a 100-cm CL provide sustainable weight loss but protein malnutrition and vitamin deficiencies [59]. In a prospective study on 25 patients with AL of 150cm were compared with 25 patients with CL of 100-150 cm, both with BPL of 50cm. Short CL have increased risk of nutritional deficiencies and malnourished patients could have high complication rates after surgery and the study advise to perform a proximal gastric bypass as the operation of first choice in patients with morbid obesity [60]. CL/total bowel length range between 0.4-0.43 and a CL length between 200cm and 220 cm might have a positive impact on comorbidities remission and nutritional deficiencies [61]. The CL is charged in the development of nutritional problems. The minimal length of the CL could provide the best weight loss and comorbidities reduction but it has an impact on the nutritional issues. A BPL less than 200cm and a CL more than 200 cm prevent the nutritional problems. It requires to follow up the proteins and vitamins issues by a multidisciplinary team because it's a high risk [62] (Table 4).

Study	No.of patients	AL (cm)	BPL (cm)	CL (cm)	WL	Nutritional Deficiencies
Abellan L, et al.	151	150	200	0	0	1
Rawlins, et al.	29	0	0	100	0	1
Tovae, et al.	250	150	120	0	0	1
Chen, et al.	2397	0	0	<400	0	1
Muller, et al.	50	0	50	0		1
Lee, et al.	165	0	150	0	1	0
Orci, L.	review	0	100	0	1	0
Risstad, et al.	113	150	50	0	0	1

Table 4: Influence on the limb length on the nutritional deficiencies.

Conclusion

According to the studies in term of weight loss the size of AL of 150-200 cm and BPL between the 100-150cm is mostly recommended as a positive weight loss effect in the RYGB setting. A BPL more than 150 cm can provide more benefit for the patients with BMI >50 kg/m^2. In term of comorbidities reduction, the results indicate positive results for T2DM between 150cm and 200cm for the BPL, and for other comorbidities like HTA or metabolic syndrome the lengths are for BPL of 200 cm, AL of 150 cm and CL of 200 cm. To minimize the negative impact of the nutritional deficiencies, the recommendation is that a CL should be between 100cm-150 cm, a BPL of 150 cm and an AL 150cm or an AL+CL 400cm-450cm can help. Concerning the gastric pouch, the volume should be between 25ml and 30ml and the diameter of the gastro-jejunal anastomosis between 2.5cm and 3 cm. Further studies are still necessary to define more accurately the optimal sizes of the limbs in RYGB and mostly the complex correlations with the dynamics of the weight loss and comorbidities control.

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