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REVIEW

"What Really Matters When Performing a Laparoscopic Roux-en Y Gastric Bypass?" Literature-Based Key Steps Towards Success and Standardization of the Procedure

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Abstract
Lack of standardization in the Roux-en-Y gastric bypass (RY-GBP) is quite well established. We all learned the basics of the technique, but a lot of differences do exist in performing each step of the procedure. Based on scientific evidences, coming from an extensive and meticulous review of the literature of the last 20 years, we thus address the different technical steps of the procedure and their importance to try and propose a standardization of RYGBP. A lot of possibilities exist at each and every step of a RYGBP. They influence the postoperative complications, the end weight loss (EWL), weight regain, and resolution of obesity bounded comorbidities. Furthermore, lack of standardization leads to problems regarding comparison of scientific data in the related literature.

Keywords Gastric bypass · Key steps · Standardization · Limb length

According to many authors, the Roux-en-Y gastric bypass is the gold standard procedure in bariatric surgery and has been surpassed in numbers only by the sleeve gastrectomy. Since Mason's first description of the Roux-en-Y gastric bypass (RYGB) in 1967, the surgical technique underwent multiple modifications. Perhaps the most significant evolution however is the laparoscopic approach [1].

RYGB is a complex procedure, characterized by a long learning curve and by the absence of standardization in terms of technique. Consequently, the analysis and interpretation of the scientific literature on the subject is difficult. Of note, substantial variations in the technical steps of RYGB may greatly influence patient outcomes.

This chapter does not aim at discussing the indications for RYGB in the armamentarium of bariatric-metabolic surgery (BMS) nor will it discuss "tips and tricks" or "how I do it." Our goal is to objectively and impartially assess the essential steps of the procedure based on data provided by the most recent scientific literature on RYGB.

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In brief, RYGB consists of (1) the creation of a small gastric pouch that is separated from the more distal stomach (the "remnant"), (2) the connection of the pouch to the distal part of a transected bowel loop (the Roux limb), and (3) the connection of the proximal part of the transected loop of small bowel (the biliopancreatic limb) to the Roux limb at a distance from its connection with the gastric pouch (Figs. 1 and 2). Because by its design in RYGB the Roux limb, which originates in the infra-transverse mesocolon area, must reach the proximal stomach, it has to reach the supra-transverse mesocolon area. It can do so in 3 different ways: either in front of the transverse colon and the remnant stomach (antecolic, antegastric, or AC/AG), or posterior to the transverse colon through a passage in its mesocolon, but anterior to the remnant stomach (retrocolic, antegastric, or RC/AG), or, finally, posterior to both the transverse colon and the remnant stomach (retrocolic, retrogastric, or RC/RG).

Retrocolic and Retrogastric (RC/RG) or Antecolic and Antegastric (AC/AG)

In 2007 Müller et al [2] compared the 3-year follow-up of patients in their practice with either an RC/RG or an AC/AG bypass construction. They found a reduced operating time and hospital stay in the latter group. Conversely,

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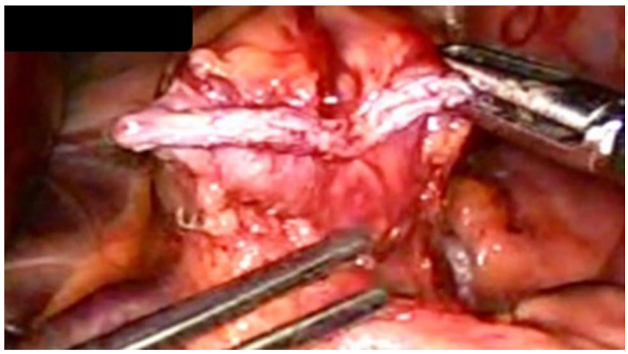

Fig. 1 Gastric pouch

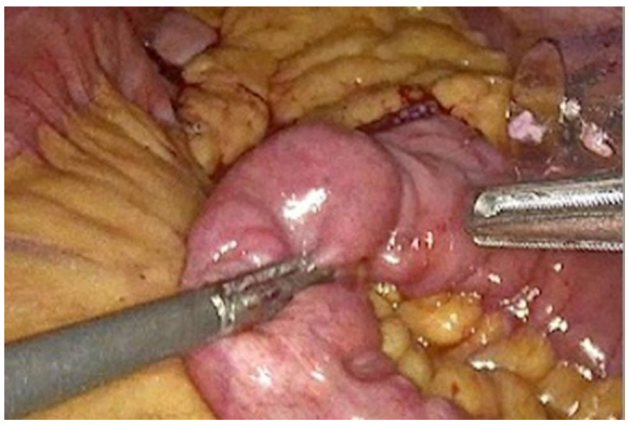

Fig. 2 Positioning the loops

regarding morbidity and weight loss, no differences were found between the 2 groups [2].

In the same year, Ahmed [3] reported an incidence of internal hernias of 0.6% (2/357) with the AC technique versus 2.4% (52/2215) in the RC group (odds ratio = 4, P <0.05).

In 2017 a meta-analysis by Ayman [4] reported collected data on 4805 patients with the AC/AG and 2238 with the RC/RG technique. The AC/AG approach was associated with a much lower incidence of internal hernias and occlusions than the RC/RG approach. Of note, in this study, 45% of patients in either group benefited from closure of the mesenteric defects. The importance of this very detail will be discussed later in the current manuscript.

In recent years, the AC/AG pathway has become the most popular. Interestingly, one of the top experts BMS surgeons, Kelvin Higa, switched from the RC/AG to the AC/AG technique in most cases, because of technical reasons, i.e., the absence of a mesocolic defect that requires closure (Fig. 3).

Gastric Pouch Size, Anastomosis Size

There is persisting controversy regarding the influence of the gastric pouch size on the pace of weight loss, on the occurrence of marginal ulcers, and on other conditions.

Edholm and colleagues [5] retrospectively assessed some 14,000 patients 1 year postoperatively. The standard size of the pouch was 14.5cm. The size, however, had no influence on the percentage of weight loss, at least in the short term (6 weeks). Conversely, the relative risk of occurrence of symptomatic marginal ulcer increased 14% for each additional centimeter of stapler used for the pouch, while the overall rate was 0.9%.

Riccioppo and colleagues [6] evaluated weight loss and food tolerance depending on the gastric pouch volume (less than or greater than 40 ml) and its emptying rate.

A smaller pouch was associated with faster gastric emptying, better food tolerance, and greater maintenance of weight loss. In terms of pouch geometry, the authors advocated a narrow and long pouch, the vertical section being parallel to the small curvature, passing through the angle of His.

In a systematic review, Mahawar [7, 8] found that larger pouches and/or greater anastomotic sizes were related to adverse weight loss outcomes. Larger pouches appeared also to be associated with a higher incidence of marginal ulcers. However, Mahawar's data did not incorporate accurate pouch size nor stoma size. Nevertheless, the authors concluded the optimal size of the pouch to be 30 ml. (7.8)

Ramos et al [9] focused on the dimensions of a linear stapled anastomosis in terms of mid-term weight loss outcomes. A 15-mm anastomosis appeared to be associated with greater weight loss compared to an estimated 45-mm anastomosis; however, at the cost of a higher stenosis rate, the cut-off is a diameter under 22mm [9].

Jiang et al [9] published a meta-analysis on the use of a mechanical (linear or circular) versus manual anastomosis. They included 13,626 patients (3309 with manual suture,

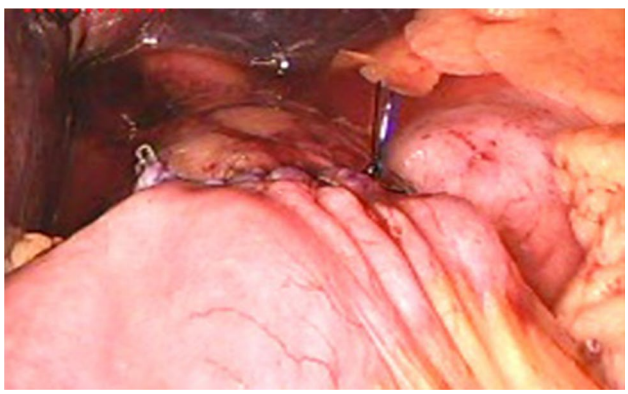

Fig. 3 Antecolic

6791 with circular suture, 3526 with linear suture) and found no difference between manual suture and linear stapled anastomosis but assessed that circular stapled anastomosis was associated with a higher incidence of postoperative bleeding and wound infections [10]. In a review study, Giordano et al [11] focused further on the type of mechanical (circular versus linear) suture. They reviewed a total of 8 publications comprising 1321 patients and found a lower risk of wound infection and stenosis, as well as a lower operative time for the linear stapler technique.

Marginal (Gastro-enteral) Anastomotic Ulcers

Anastomotic ulcers constitute an important entity on their own. Their reported incidence ranges from 1 to 16 %, and their appearance may be facilitated by chronic irritation caused by the foreign material of the anastomotic suture. Consequently, resorbable suture material may be less ulcerogenic [12, 13].

Reinforcement of the Gastro-jejunal Suture

Complications, specifically located at the level of the staple lines, mainly include leaks and/or bleeding. The aforementioned conditions were studied in a meta-analysis by Shikora in 2015 [14], who collected 16,967 articles published between the beginning of January 2000 and the end of December 2013, gathering post-RYGB or post-LSG data from 56,309 patients (fistulas) and 41,864 patients (bleeding) respectively. Confounding factors at study were no reinforcement (40% of cases) oversewing, buttressing with biocompatible glycoside copolymer or buttressing with bovine pericardium. In the former group, the leak rate was the highest (2.75%), and the bleeding rate was 3.45%. Simple suture reinforcement was better than no reinforcement (leak rate 2.45% and bleeding rate 2.69%). Of note, there was no consensus regarding the type of suture to be made nor in the type of suture material.

In addition, suture reinforcement appeared to result in more ischemia at the level of the staple line, and additional costs and time spent at suturing led many not to use it. Conversely, staple buttress reinforcement was accompanied by fewer problems, with an obvious advantage for bovine pericardium (leak rate 1.28% and bleeding rate 1.23%) versus biocompatible glycoside copolymer (leak rate 2.61% and bleeding rate 2.48%) [14]. Many additional confounding factors however were not addressed in this meta-analysis. They include age of the patient, comorbidities, type of staples, the stapler itself, the size of the pouch, the bougie used, etc.

Sub-total Gastrectomy

Standard RYGB no longer allows straightforward endoscopic access to the gastric remnant, which may be an issue in individuals at risk for gastric malignancy, such as patients with a family history of stomach cancer or with demonstrated potentially precancerous lesions, e.g., intestinal metaplasia or Biermer's disease. The inaccessibility of the gastric remnant may indicate resection of the latter, be it in exceptional cases [15–17].

RYGB With or Without Band

Bariatric surgery provides great results in terms of inducing and keeping weight loss in most patients with obesity. Nevertheless, some patients will regain weight over time, including after RYGB. This very issue was extensively studied by Fobi [18]. He proposed the placement of a band on the gastric pouch [18]. In 2014, H. Buchwald [19] published the first systematic review and meta-analysis exclusively considering the medium-term results for the banded RYGB (B-RYGB) in the time span between 1990 and 2013. He analyzed the outcomes in terms of weight loss, complications, and comorbidities and reported better midterm maintenance of weight loss in patients who benefited from a B-RYGB.

Lemmens [20] similarly reported better results of the B-RYGB both in revisional surgery for weight regain and in first intention procedures. Nevertheless, nowadays, B-RYGB is not (yet) considered as a standard procedure.

Size of the Alimentary, Biliary, and Common Loop

The length of the different intestinal components of the RYGB is a key point with great repercussion on the evolution of weight, comorbidities, deficiencies, and malnutrition.

Dogan and colleagues [21] reported retrospectively the data on 768 consecutive patients who underwent RYGB between January 2001 and March 2011; 360 patients (47%) benefited from a short (100 cm) alimentary loop (SAL) and 418 patients (53%) a 150 cm alimentary loop (LAL). The mean follow-up was 37 ± 26 (range 0–120) months. Results were comparable for both groups: the percentage of excess weight loss (%EWL) at 2 years was 33 ± 9% and 28 ± 12% at 5 years in each group, and no difference was reported in terms of complications.

Interestingly, in a publication, the following year [22, the same team switched focus from AL to BL in a randomized trial in 146 patients covering a follow-up of 4 years on average. In 74 participants, the RYGB was constructed

Fig. 4 Evolution of the percentage of weight loss in patients with a short or a long alimentary loop after different months. Homan J., Boerboom A., Aart, E. et al [22]

with a long AL (150 cm) and a short BL (75 cm) (group 1); in 72 participants, AL was 75 cm and BL 150 cm (group 2). The results were better in group 2 (22, Fig. 4).

In 2019 Shah et al [23] retrospectively reviewed 671 patients followed for 10 years. The patients were divided into 3 groups according to the size of the different intestinal segments. Patients with a long biliary loop reached greater excess (EWL) and total (TWL) weight loss and less weight regain, together with better resolution of obesity-related comorbidities. Complication rates were comparable, except for a higher frequency of marginal ulcers in patients with a shorter alimentary loop [23, 24], Table 1. Interestingly, no literature data could be retrieved about length of the common limb in standard RYGB, which may well be an important shortcoming.

Closure of Defects

Routine closure of the mesenteric-mesenteric defect at the jejuno-jejunostomy and the mesenteric-transverse mesocolic space (Petersen) is considered a must by most, albeit not all authors. This closure must be made with non-absorbable material, be it threads, running suture, separated stitches, or staples. At this time, no superiority of one method over the other has been demonstrated.

The occurrence of internal hernias is a potentially life-threatening complication after RYGB. However, inadequate closure of these spaces may induce equally serious complications, ranging from maintained small defects left to iatrogenic torsion of the small bowel [25].

Leak Tests: Methylene Blue/Air/ICG

There are several ways to check suture integrity at the end of the procedure [26]. An adequate leak test is obviously of the utmost importance, because the per operative detection of a leak allows to correct hidden flaws and thus avoid potential complications.

Closure of Trocar Ports

Patients with obesity usually have a weak abdominal wall, which enhances the risk of trocar site hernia. In addition, closing the fascia at a trocar incision is technically challenging in individuals with a substantial subcutaneous fat layer. The issue of trocar site hernia in bariatric surgery has been extensively studied by Karampinis and colleagues [27] who performed a systematic review and meta-analysis of 68 related publications. They concluded that this complication was highly underestimated.

Conclusions

The different points considered in this paper may help in establishing a standard in RYGB technique. We propose a small (rather long but narrow) gastric pouch with a capacity of about 30 ml, anastomosed with an ante gastric-antecolic alimentary loop of 70 to 100 cm by means of a linear or manual anastomosis of not less than 22 mm in diameter. Reinforcing the staple lines may be helpful to avoid leaks and/or bleeding. The biliary loop that joins the alimentary loop to constitute the common part should probably measure some 150 cm. At the end of the procedure, the mesenteric and Petersen defects should be hermetically closed with non-absorbable material. At the conclusion of the procedure, a leak test should probably be done. Despite the technical difficulty, the fascia at the trocar sites should be closed.

Table 1. Percentages of weight regain, deficiencies and resolution of comorbidities in relation to alimentary and biliary loops of different sizes. Includes 671 patients with a follow-up time of 10 years. Sha et al [23]

Alimentary loop size and number of patients	Biliary loop size and number of patients	Weight regain	Deficiencies	Resolution of comorbidities
155 p 150 cm	60 cm	10.3%	3.9%	+
230 p 60 cm	200 cm	4.3%	5.9%	+++
286p 150 cm	200 cm	5.2%	5.9%	+++

Declarations

This article does not contain any studies with human participants or animals performed by any of the authors.

Ethical approval For this type of document, formal consent is not required, and informed consent does not apply.

Conflict of Interest The authors do not have any conflict of interest.

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