Limb length in bariatric surgery of Roux-en-Y gastric bypass (RYGB): An integrative review

Bruno Landal Cavassin1, Carolina Cabral Brandalizze1

Abstract

Introduction: Roux-en-Y gastric bypass is considered the gold standard surgical technique for obesity. The variation in limb length may be related to metabolic improvement and nutritional deficiencies. However, the ideal measurement is still a controversial subject in the literature. This study aims to perform an integrative literature review and associate the optimal limb length, considering the maximum weight loss with the minimum nutritional complications. Methods: Integrative literature review conducted using electronic searches (1992 - 2020) in databases MEDLINE/Pubmed and BVS (Biblioteca Virtual da Saúde)/LILACS, through the terms “(bariatric surgery) AND (limb length)”. A total of 340 articles were found, 26 articles were included in this review. Results: Current evidence supports using shorter limb lengths in patients with BMI < 50 kg/m², and longer limbs in patients with severe type 2 diabetes mellitus and/or dyslipidemia or superobese patients (BMI ≥ 50 kg/m²), considering the benefits in comorbidities resolution. A shorter common limb increases the incidence of nutritional disorders. There is a wide variation in jejunoileal length among patients. Conclusion: Measuring the intraoperative jejunoileal length and individualizing the surgery may bring benefits in weight loss, comorbidities resolution, and reduce the incidence of nutritional disorders. However, more randomized controlled trials are needed on this topic.

Keywords: bariatric surgery; gastric bypass; obesity; morbid obesity; obesity management; small intestine.

Resumen

Introducción: el bypass gástrico en Y de Roux se considera la técnica quirúrgica estándar de oro para la obesidad. La variación en la longitud del asa intestinal puede estar relacionada con la mejora metabólica y las deficiencias nutricionales, sin embargo, la longitud ideal sigue siendo un tema controvertido en la literatura. El objetivo de este estudio es realizar una revisión integradora de la literatura y asociar la longitud ideal del asa intestinal, considerando la máxima pérdida de peso con las mínimas complicaciones nutricionales. Materiales y Métodos: revisión bibliográfica integradora realizada mediante búsquedas electrónicas (1992 - 2020) en bases de datos MEDLINE/Pubmed y BVS (Biblioteca Virtual da Saúde) / LILACS, a través de los términos “(bariatric surgery) AND (limb length)”. Se encontraron un total de 340 artículos, 26 artículos fueron incluidos en esta revisión. Resultados: la evidencia actual respalda el uso de asas intestinales más cortas en pacientes con IMC < 50 kg/m² y asas intestinales más largas en pacientes con diabetes mellitus tipo 2 grave y/o dislipidemia o pacientes superobesos (IMC ≥ 50 kg/m²), considerando los beneficios en la resolución de comorbididades. La asa común más corta aumenta la incidencia de trastornos nutricionales. Existe una amplia variación en la longitud yeyunoileal entre los pacientes. Conclusiones: la medición de la longitud yeyunoileal intraoperatoria y la individualización de la cirugía pueden traer beneficios en la pérdida de peso, la resolución de comorbididades y reducir la incidencia de trastornos nutricionales. Sin embargo, se necesitan más ensayos controlados aleatorios sobre este tema.

Palabras clave: cirugía bariátrica; derivación gástrica; obesidad; obesidad mórbida; manejo de la obesidad; intestino delgado.

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(1) School of Medicine, Pontifical Catholic University of Paraná, Curitiba, PR, Brazil
Corresponding author: brunocavassin@gmail.com
Introduction

Obesity represents a substantial part of the global health problem. Defined as excess body fat and body mass index (BMI) above 30 kg/m², this disease is associated with an increased risk of type 2 diabetes mellitus (DM2), systemic arterial hypertension, coronary disease, cerebrovascular disease, and different types of cancers (Engin, 2017).

The main points of obesity treatment are lifestyle change (LSC) and/or pharmacological treatment and/or surgical treatment. Currently, the world performs more than 800 thousand bariatric surgeries per year, which is considered, in association with LSC, the most effective long-term technique for treating this disease. Vertical gastrectomy (sleeve) is the most performed bariatric surgery in the world, with 47%. Roux-en-Y gastric bypass (RYGB) has second place, with 35.3% (Ramos et al., 2019).

RYGB, considered the gold standard surgery by many authors, leads to an excess weight loss (%EWL) between 60-80% and consists of creating a small gastric pouch associated with intestinal bypass. This method combines the restrictive with the malabsorptive technique. The intestinal bypass is characterized by the creation of 3 limbs: alimentary limb (AL), biliopancreatic limb (BL), and common limb (CL) (Figure 1). RYGB is associated with significant metabolic improvements and often a reversal of arterial hypertension, DM2, dyslipidemia, and sleep apnea (Ramos et al., 2019). However, it can be associated with nutritional deficiencies, such as proteins, iron, zinc, and vitamins B12 and D (Sampaio-Neto et al., 2016).

The variation in limb length may be related to metabolic improvement and possible nutritional deficiencies. Therefore, the ideal measurement is still a subject to be clarified in the literature (Ahmed et al., 2019).

Through an integrative literature review, this study main aim is to evaluate the limb length in Roux-en-Y gastric bypass and the association with the BMI and comorbidities in the pre-operatory period, as well as considering the ideal limb length to generate a better postoperative outcome, contemplating the maximum weight loss with the minimum possible nutritional disorders.

Methods

We performed an integrative literature review using electronic searches (1992-2021), which used the terms "(bariatric surgery) AND (limb length)" in the MEDLINE/Pubmed and BVS (Biblioteca Virtual da Saúde)/LILACS databases. In addition to the articles found in the databases, some studies in the references of the analyzed articles were included.

The selection criteria included articles published in English, Portuguese and Spanish, that were chosen according to the fulfillment of the previously established selection criteria that correspond to: (1) adults over 18 years old undergoing RYGB bariatric surgeries. (2) RYGB bariatric surgeries correlate the jejunoleval length and/or the alimentary limb and/or biliopancreatic limb and/or common limb. (3) Outcomes associated with weight loss and/or nutritional deficiencies during the postoperative period. Articles that did not correlate the limb length, studies performed on animals, and case reports were excluded.
Two researchers recorded the information from each study separately upon assessment of the risk of bias and results. When discrepancies occurred, the final decision was made by consensus. A total of 340 articles were found, 96 were duplicates, and 176 articles were excluded. Sixty-eight papers were read in full. Twenty-six articles were selected to compose this integrative review of the literature (Figure 2).

Figure 2: Studies selection flowchart

Results

A longer alimentary limb is beneficial in superobese

Brolin et al. (1992) published the first randomized study that studied the variation of limb length in superobese patients, defined as BMI $\geq 50$ kg/m$^2$. Greater %EWL was reported in the group with longer limbs (AL 150 cm, BL 30 cm (AL + BL = 180 cm)), without significant vitamin deficiencies and/or diarrhea after three years. (Ciovica et al., 2008); Gleysteen, 2009 in a prospective and retrospective study, respectively, also obtained a greater %EWL with longer AL in superobese patients.

Gan et al. (2018), after a systematic review of the literature and meta-analysis with 1714 patients, recommend an AL 130-150 cm for superobese patients and AL 40–100 cm for non-superobese patients. Stefanidis et al. (2011), in another systematic review, also considered that patients with a BMI $\geq 50$ kg/m$^2$ should receive an AL $\geq 150$ cm.
Different lengths are associated with metabolic improvement

Kaska et al. (2014) concluded that the differences in measures did not influence weight loss, but there were more cases of DM2 remissions in patients with AL close to 150 cm and BL 100 - 150 cm. These authors also recommend CL > 150 cm.

Pinheiro et al. (2008) reported that superobese patients with AL 250 cm, BL 100 cm (AL + BL = 350 cm) had better control of DM2 (p < 0.05) and dyslipidemia (p < 0.05), if compared with patients of AL 150 cm, BL 50 cm (AL + BL = 200 cm), without major nutritional differences. The authors cite that one of the possible causes for the improvement of DM2 and dyslipidemia is the longer length of the BL, characterizing a lesser circulation of free fatty acids in the portal circulation.

Nora et al. (2017) studied patients with BMI < 50 kg/m² and concluded that AL 120 cm and BL 200 cm (AL + BL = 320 cm) are superior in DM2 remission and %EWL compared to AL 120 cm and BL 84 +/- 2 cm (AL + BL ~ 200 cm), without major nutritional complications between groups after 5 years.

Homan et al. (2018) in a randomized controlled study, concluded that AL 75 cm, BL 150 cm (AL + BL = 225 cm) had a higher %EWL (p = 0.049) and more remission of dyslipidemia (p = 0.022), if compared to AL 150 cm, BL 75 cm. DM2 remission, arterial hypertension, and nutritional complications were similar between the two groups after four years.

Different lengths are not associated with weight loss

Choban & Flancbaum (2002) compared the influence of the alimentary limb on non-superobese and superobese patients. After three years, the authors concluded that there was no significant benefit from longer limbs. In patients with CL 250 cm, no case of protein-calorie malnutrition or calcium deficiency was noted.

Christou et al. (2006) compared non-superobese and superobese after ten years of follow-up. Similar weight loss has been reported between AL 40 cm, BL 10 cm (AL + BL = 50 cm) and AL 100 cm, BL 100 cm (AL + BL = 200 cm).

Valezi et al. (2014) randomized 120 patients (mean BMI 46 kg/m²) in 4 groups with AL + BL ranging from 150 to 250 cm. No relationship was found between limb length and weight loss after one year postoperatively. In studies with similar AL + BL, (Inabnet et al., 2005; Ramos et al., 2016) also found no significant difference in weight reduction after two years.

Sarhan et al. (2011) concluded that there was no difference in %EWL and complications between AL 170-200 cm compared to AL 120-150 cm in superobese patients for three years (BL 50-80 cm in both groups).

Longer bypass can lead to worsening quality of life and/or more significant nutritional deficiency

Risstad et al. (2016) carried out a double-blind, randomized study with only superobese patients. Patients with CL 150 cm had more diarrhea, secondary hyperparathyroidism, and lower albumin levels, with similar %EWL (p = 0.032). Nergård et al. (2020), in another randomized study, also concluded that patients with CL 150 cm had a higher incidence of diarrhea (p = 0.006), without higher %EWL (p = 0.085), even after five years.

Ruiz-Tovar et al. (2019) studied 506 patients in a prospective randomized study. Group 1 (BMI 44.2 +/- 5.2 kg/m²): BL 70 cm (AL + BL = 220 cm) vs. Group 2 (BMI 44.1 +/- 4.1 kg/m²): BL 120 cm (AL + BL = 270 cm). The authors concluded no difference between the groups for weight loss, DM2 remission, dyslipidemia, and hypertension. However, the group with longer limbs was associated with a greater deficiency of vitamin B12, vitamin A, and folic acid over five years.

(Savassi-Rocha et al., 2008; Tacchino, 2015) suggest measuring jejunileal length to avoid more significant nutritional deficiencies. Like Chen et al. (2019), as they concluded that CL < 400 cm was related to a greater protein deficiency. Ghiasi et al. (2018) concluded that diarrhea and malabsorption usually occur when the patient has an AL + CL < 250-300 cm, but with improvement after reparative surgery for AL + CL of 400-450 cm.

Nergård et al. (2014), in a randomized study, mentioned that AL 60 cm, BL 200 cm (AL + BL = 260 cm) despite being superior in weight loss compared to AL 150 cm, BL 60 cm (AL + BL = 210 cm), are associated with greater iron and vitamin D deficiency, as well as diarrhea and similar resolution of DM2, arterial hypertension and sleep apnea in both non-superobese and superobese after seven years. According to a systematic review (Mahawar et al., 2016), the best results occur when AL + BL = 100-200 cm. They mention that AL + BL > 200 cm can be considered in superobese patients, however CL < 100 cm can cause nutritional complications. Sugerman et al. (1997) said that a CL 50 cm is unacceptable due to postoperative nutritional deficiency, and a CL 150 cm can be used for superobese patients with severe comorbidities. However, it is preferable to use a CL > 200-250 cm.

Gadiot et al. (2020) reported a higher rate of laparoscopic reinsertion and greater calcium, iron, and vitamin D deficiencies in the group with variable AL and CL 100 cm. They did not find significant differences in weight loss, resolution of DM2, dyslipidemia after one year.

All main points results are summarized in Table 1.
Anatomical variation in the length of the small intestine

In addition to the relationship between the postoperative result, a considerable variation of the small intestine length was found in the studies (Table 2). According to the studies, male individuals had longer average lengths, and no relationship was found between the length of the small intestine and the preoperative BMI.

Table 1: Articles main points according to the citation order in the text

| Study            | Type    | n  | BMI   | Lengths with better outcome | Comments                                                                 |
|------------------|---------|----|-------|-----------------------------|--------------------------------------------------------------------------|
| Brolin et al., 1992 | RCT     | 45 | SO    | AL 150 cm, BL 30 cm        | Greater %EWL, without major ND and/or diarrhea.                           |
| Covica et al., 2008    | Prosp   | 137 | SO    | AL 150cm, BL 30 cm         | Greater %EWL.                                                            |
| Gleysteen, 2009       | Retro   | 344 | NSO, SO | AL >130cm, BL 18-30cm     | Greater %EWL in superobese patients.                                     |
| Gan et al., 2018      | MA      | 1714 | SO    | AL 130-150cm               | More weight loss. Recommend AL 40–100 cm for NSO patients.               |
| Stefaniadis et al., 2011 | SR     | 1426 | SO    | AL >=150cm                 | More weight loss.                                                        |
| Kaska et al., 2014    | Prosp   | 93  | NSO, SO | AL 150cm, BL 100 -150cm    | Better DM2 resolution. Support CL >150cm to avoid ND                    |
| Pinheiro et al., 2008 | RCT     | 105 | SO    | AL 250cm, BL 100cm         | Better DM2 and dyslipidemia resolution, without major ND                 |
| Nora et al., 2017     | Prosp   | 114 | NSO   | AL 120cm, BL 200 cm        | Better DM2 control and greater %EWL, without major ND                    |
| Homan et al., 2018    | RCT     | 146 | NSO   | AL 75 cm, BL 150 cm        | Better dyslipidemia control.                                             |
| Choban & Flanchbaum, 2002 | RCT   | 133 | NSO, SO | AL 75-150cm, BL 30 cm      | Support longer AL only in SO patients.                                   |
| Christou et al., 2006 | Retro  | 228 | NSO, SO | AL 40 cm, BL 10 cm         | Longer limbs was not associated with greater %EWL.                       |
| Valezi et al., 2014   | RCT     | 120 | NSO   | AL 100cm, BL 50cm          | Longer limbs was not associated with greater %EWL.                       |
| Inabnet et al., 2005  | RCT     | 48  | NSO   | AL 100cm, BL 50cm          | Longer limbs was not associated with greater %EWL.                       |
| Ramos et al., 2016    | Retro   | 63  | NSO, SO | AL 100cm, BL 50cm          | Longer limbs was not associated with greater %EWL.                       |
| Sarhan et al., 2011   | Retro   | 120 | SO    | AL 120-150cm, BL 50-80cm   | Longer limbs was not associated with greater %EWL.                       |
| Risstad et al., 2016  | RCT     | 113 | SO    | AL 150cm, BL 50cm          | Support CL >= 150 cm, to avoid nutricional deficiencies and diarrhea.   |
| Nergård et al., 2020  | RCT     | 140 | SO    | AL 150cm, BL 60cm          | Support CL >= 150 cm, to avoid diarrhea.                                 |
| Ruiz-Tovar et al., 2019 | RCT  | 506 | NSO   | AL 150cm, BL 70cm          | BL 120 cm was associated with greater ND.                                |
| Savassi-Rocha et al., 2008 | Prosp | 100 | NSO, SO | AL 110 cm, BL~60cm         | Support CL ~400-600 cm. Suggest measuring JIL to avoid greater ND.       |
| Tachino, 2015         | Prosp   | 443 | NSO, SO | NR                         | Suggest measuring JIL to avoid greater ND.                               |
| Chen et al., 2019     | Prosp   | 377 | NSO   | AL 150 cm, BL 100cm        | Support CL > 400 cm to avoid protein deficiency.                         |
| Ghiassi et al., 2018  | Prosp   | 96  | NSO   | AL+CL >=400-450cm          | AL~100cm. Support CL >150-200cm, to avoid ND.                           |
| Nergaard et al., 2014 | RCT     | 187 | NSO, SO | AL 150cm, BL 60cm          | BL 200cm was associated with greater ND and diarrhea.                   |
| Mahawar et al., 2016  | SR      | NR  | NSO   | AL+BL 100-200cm            | Support CL >= 100cm, to avoid ND.                                       |
| Sugerman et al., 1997 | Prosp   | 27  | SO    | AL 100cm, BL 200-300cm     | CL 50 cm is unacceptable. CL 150 cm can be used for SO with comorbidities.|
| Gadiot et al., 2020   | Prosp   | 444 | NSO, SO | AL 150cm, BL 60cm          | CL < 100 cm was associated with greater ND.                              |

Abbreviations: %EWL, excess weight loss; AL, alimentary limb; BL, biliopancreatic limb; BMI, body mass index; CL, common limb; DM2, type 2 diabetes mellitus; JIL, jejunoileal length; MA, meta-analysis; n, number of patients; ND, nutritional disorders; NR, not revealed; NSO, non-superobese; Prosp, prospective study; RCT, randomized clinical trial; Retro, retrospective study; SO, superobese; SR, systematic review.
Table 2: Small intestine length variation found in the analyzed articles.

| Study                              | Small intestine | Other information                                                                 |
|------------------------------------|-----------------|-----------------------------------------------------------------------------------|
| Chen et al., 2019                  | 490 – 1320 cm   | -                                                                                |
| Gadiot et al., 2020                | 355 - 985 cm    | Longer in men (p = 0.002). No relationship was found between length and BMI       |
| Gleysteen, 2009                    | 302 – 792 cm    | No relationship was found between length and BMI                                  |
| Kaska et al., 2014                 | 325 – 650 cm    | -                                                                                |
| Nergaard et al., 2014              | 420 – 870 cm    | -                                                                                |
| Savassi-Rocha et al., 2008         | 434 - 990 cm    | Longer in men (p < 0.005). No relationship was found between length and BMI       |
| Tacchino, 2015                     | 350 - 1049 cm   | Longer in men (p < 0.0001)                                                      |

Abbreviations: BMI, body mass index.

Discussion

According to the analyzed studies, bariatric surgery of RYGB is a safe and effective technique for treating obesity and associated comorbidities. Although several studies correlate limb length with excess weight loss and nutritional deficiencies in patients undergoing RYGB, the heterogeneity of measures and follow-up still maintains this controversial subject in the literature. A possible limitation is the accuracy of the measurement of the limb lengths, as there may be variations during the laparoscopy technique (Tacchino, 2015). However, despite the limitations, the studies present in this review could guide future studies and strategies in decision-making about RYGB surgery.

Some studies show benefit from %EWL with more prolonged intestinal bypass in superobese patients (BMI >= 50 kg/m²). In these patients, an AL close to 150 cm or AL + BL = 200-300 cm can bring a good %EWL with minor nutritional deficiencies (Brolin et al., 1992; Ciovica et al., 2008; Gleysteen, 2009; Stefanidis et al., 2011; Gan et al., 2018). However, there is evidence that concludes that the limb length does not influence the postoperative result. In patients with a BMI < 50 kg/m², an AL 75-100 cm with BL 50-100 cm (AL + BL = 100–200 cm) also let to a proper %EWL without more significant nutritional deficiencies (Choban & Flancbaum, 2002; Inabnet et al., 2005; Christou et al., 2006; Sarhan et al., 2011; Valezi et al., 2014; Mahawar et al., 2016; Ramos et al., 2016; Risstad et al., 2016; Ruiz-Tovar et al., 2019; Gadiot et al., 2020; Nergård et al., 2020). In cases of patients with severe comorbidities, like severe DM2 and/or severe dyslipidemia, probably longer BL could be beneficial aimed comorbidities resolution, and specific evidence supports a BL close to 150 cm in those patients (Pinheiro et al., 2008; Kaska et al., 2014; Nora et al., 2017; Homan et al., 2018).

Several studies mention that very short common limb can lead to severe protein malnutrition, higher nutrient deficiency, and diarrhea, especially if < 150 cm. CL ideally longer than 250-400 cm may decrease the incidence of nutritional disorders, confirming the importance of measuring the intraoperative jejunooileal length and individualizing the surgery due to the wide variation in the small intestine of patients (Sugerman et al., 1997; Savassi-Rocha et al., 2008; Kaska et al., 2014; Nergaard et al., 2014; Tacchino, 2015; Mahawar et al., 2016; Risstad et al., 2016; Ghiassi et al., 2018; Chen et al., 2019; Ruiz-Tovar et al., 2019; Gadiot et al., 2020; Nergård et al., 2020).

The limb length is essential; however, long-term weight loss is influenced by several variables, mainly by changes in lifestyle and also by the restrictive component of the gastric pouch. Therefore, further studies are needed, essentially long-term controlled and randomized studies, which correlate the length of the three intestinal limbs with the patients’ jejunoileal measurement.

In the future, perhaps the routine of the bariatric surgeon will include measuring the intraoperative jejunooileal length, and with this question clarified, they will be able to perform more individualized surgeries that help the patient with significant weight loss, in addition to improving metabolic diseases, and possibly generating a lower rate of nutritional disorders and revisional surgical approaches.

Conclusion

There is a lack of consensus and varying opinions among experts about the limb lengths in RYGB surgeries. Otherwise, current evidence supports using shorter limb lengths in patients with BMI < 50 kg/m² and longer limbs in patients with severe DM2 and/or dyslipidemia or superobese patients (BMI >= 50 kg/m²) considering the benefits in %EWL and comorbidities resolution. Common limb < 150 cm increases the incidence of nutritional disorders, confirming the importance of measuring the intraoperative jejunooileal length and individualizing the surgery. However, there is high heterogeneity in the studies, highlighting the importance of future randomized trials on this topic.
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