

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

Longitud del asa intestinal en la cirugía bariátrica de bypass gástrico en Y de Roux (BGRY): Una revisión integradora

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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 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 comorbilidades. La asa común más corto 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 comorbilidades 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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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-operative 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.

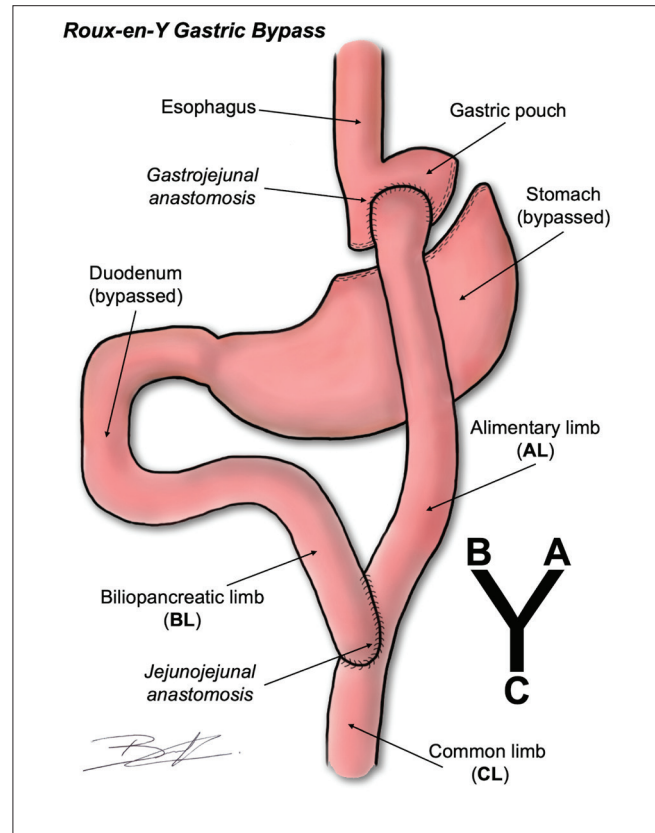


Figure 1: Schematic figure of the surgical aspect of RYGB (Author: Cavassin, BL).

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 jejunioileal 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).

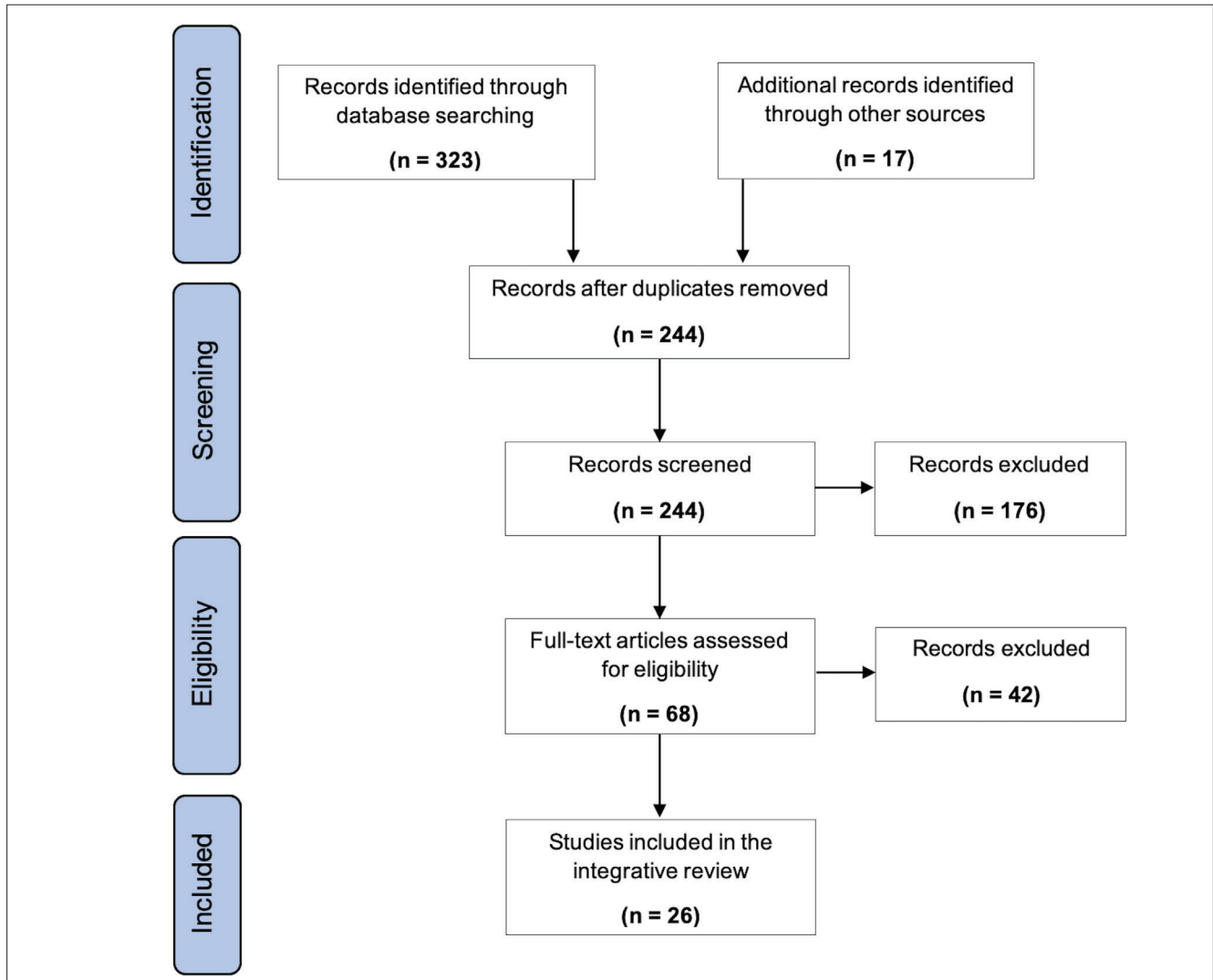


Figure 2: Studies selection flowchart

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 ≥ 50 kg/m². 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 ≥ 50 kg/m² should receive an AL ≥ 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 jejunoleal 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. Ghiassi *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.

Nergaard *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 reintervention 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.

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

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

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 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 \geq 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 jejunoileal 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 jejunoileal 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 \geq 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 jejunoileal 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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