Scientific Research Publishing

Surgical Science, 2023, 14, 474-485
https://www.scirp.org/journal/ss
ISSN Online: 2157-9415
ISSN Print: 2157-9407

Gastroenteroanastomosis Techniques for Laparoscopic Gastric Bypass: Linear vs Circular Stapler

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How to cite this paper: Netto, M., Tinoco, A., Bôa, I.F. and Duval-Araújo, I. (2023) Gastroenteroanastomosis Techniques for Laparoscopic Gastric Bypass: Linear vs Circular Stapler. *Surgical Science*, **14**, 474-485.
https://doi.org/10.4236/ss.2023.147052

Received: June 10, 2023
Accepted: July 17, 2023
Published: July 20, 2023

Abstract

Background: Laparoscopic Roux-en-Y gastric bypass (LRYGB) is an effective and well-accepted procedure for the treatment of morbid obesity but has complications such as stenosis of the gastroenteroanastomosis (GE), GE leak, surgical site infection, and stapling malfunction. This study evaluated the efficiency of weight loss and the incidence of short- and mid-term postoperative complications in patients undergoing LRYGB in which anastomosis was performed using a linear stapler (LSA) or a circular stapler (CSA). **Methods:** Prospective observational study conducted between April 2016 and March 2019. The data were extracted from a hospital database that includes patients undergoing LRYGB in two different GE techniques, assessing postoperative complications and excess body weight loss. **Results:** Data from 457 patients were analyzed, of which 216 were in the LSA group and 241 were in the CSA group. There were four cases (1.7%) of GE stenosis in the CSA group and only one (0.5%) in the LSA group. Stapler malfunction occurred in both groups: CSA (0.4%) and LSA (0.5%), and a GE leak developed only in the CSA group (0.4%). Surgical site infection was found in five patients in the CSA group (2.1%) and two in the LSA group (0.9%). No statistical difference was found between the two groups in any of the variables analyzed ($p > 0.05$). **Conclusions:** Both stapling techniques resulted in a similar loss of excess body weight during the follow-up period. Although the LSA group had fewer total complications, these were not statistically significant, which substantiates the fact that both techniques are safe and feasible, provided they are performed by a surgeon with a long learning curve in laparoscopic bariatric surgery.

Keywords

Gastric Bypass, Roux-en-Y, Obesity, Bariatric Surgery, Surgical Stapling,

Postoperative Complications

1. Introduction

Obesity is considered a major global public health issue and has increased significantly in the West in the last two decades. It is currently estimated that around two billion individuals are overweight and more than 650 million adults are obese in the world [1]. Overweight and obesity increase the risk of developing cardiovascular disease, diabetes, hypertension, and cancer [2] [3].

In Brazil, there is a significant progressive increase in obesity in all age groups. From 2006 to 2017, this tendency was concentrated in the capital cities, and was greater among women [4] [5].

Since the advent of laparoscopic bariatric surgery by Wittgrove *et al.* in 1994 [6], several techniques have been developed [7] [8], with LRYGB being one of the most widely accepted and commonly performed surgeries, reaching excellent results compared to other purely restrictive techniques [9] [10]. LRYGB accounts for about 40% of bariatric procedures performed in the United States [11].

Three types of gastroenteroanastomoses (GE) are commonly performed in LRYGB: circular-stapled (CSA), linear-stapled (LSA), and hand-sewn (HSA) [12]. In all GE both early and late complications can occur. Among the early complications with the use of automatic staplers, the most important are bleeding and GE leaks. Among late complications, GE stenosis is considered the most common [13]. Many authors suggest that there is a greater number of GE stenosis when circular staplers are used. Among the main studies, *Sczepaniak and Owens* (2009) [14] in their work with 214 patients (100 in the linear group and 114 in the circular group) showed that 16 patients presented GE stenosis in the circular group and zero patients in the linear group ($p < 0.001$), Leyba *et al.* (2008) [15] in a randomized controlled trial with 80 patients (40 patients in each group), observed seven cases of stenosis in the circular group and one in the linear group ($p < 0.05$), and *Alexander C Barr et al.* (2019) [16] with 171 patients (81 patients in the linear group and 88 in the circular group), showed 17 cases of stenosis in the circular group and 02 in the linear group ($p < 0.01$). Among the reasons for these results suggested by the authors, the smaller size of the anastomosis with a circular stapler (21 or 25 mm), the type of reinforcement suture employed, and gastroesophageal reflux are believed to be possible causes of higher stenosis rates.

The current literature is still unclear about the predilection of the GE anastomosis technique, and whether the learning curve in laparoscopic surgery would be more relevant than the chosen technique.

Through a preliminary observation, we did not find data in the study of cases from Hospital São José do Avaí (HSJA) that indicated that there is such a relation, and due to this uncertainty regarding the existence of this result, it was

considered valid to evaluate in a series of patients operated by the same bariatric surgeon, who overcame the learning curve in LRYGB, the postoperative evolution of patients submitted to this surgery, in which GE was performed with a circular or linear device.

2. Case Selection and Method

This study was entered in the Brazil platform and approved by the ethics and research committee of Iguaçu University, campus V, under registration No. 23300719.0.0000.5288, and all methods were performed in accordance with the relevant guidelines and regulations. The need for informed consent was waived by the ethics committee (5288-Universidade Iguaçu-Campus V/Itaperuna-UNIG) due to retrospective nature of the study.

This is a prospective observational study conducted from April 2016 to March 2019 at Hospital São José do Avaí (Itaperuna-RJ), in patients undergoing two different techniques of GE in the LRYGB, performed by the same surgeon. Patients who had undergone other laparoscopic or endoscopic bariatric surgery techniques prior to LRYGB, prior laparotomy for any other reason, and patients without regular postoperative follow-up were excluded from the study. The aim of this study was to compare, in patients undergoing GE using a linear or circular stapling device, the loss of excess weight and to identify possible complications in the immediate postoperative period, at 30, 180 and 360 days.

Weight loss was assessed by the percentage loss of excess weight in each group, calculated by total weight lost × 100, divided by excess weight. Excess weight was calculated by current weight minus target weight (BMI 25 kg/m^2).

$$\text{Excess weight} = \text{CURRENT WEIGHT}\left(\text{KG}\right) - \text{TARGET WEIGHT}\left(\text{BMI } 25\,\text{kg}/\text{m}^2\right)$$

$$\%\ \text{EXCESS WEIGHT LOST} = \frac{\text{WEIGHT LOST }\left(\text{KG}\right)\times 100}{\text{EXCESS WEIGHT}}$$

All patients were submitted to pre- and post-operative evaluations and follow-up by a multidisciplinary team composed of a surgeon, an endocrinologist, a psychologist, a nutritionist, and a physical therapist. The final appearance of LRYGB may be seen in **Figure 1**.

2.1. GE Techniques

2.1.1. Linear

After dissecting the angle of Hiss and opening the small omentum near the small curvature of the stomach, the gastric pouch was created using a horizontal and two to three vertical loads of a linear stapler (Reach® Linear Stapler ENDORLC4535R 45 mm). Next, GE was performed with a linear stapler (Reach® Linear Stapler ENDORLC4525R 45 mm), firing the stapler at the 30 mm setting, and closing the stapler entrance hole by continuous manual suturing, using an absorbable thread(PDS 3-0 Covidien®, MA, USA) to (**Figure 2**).

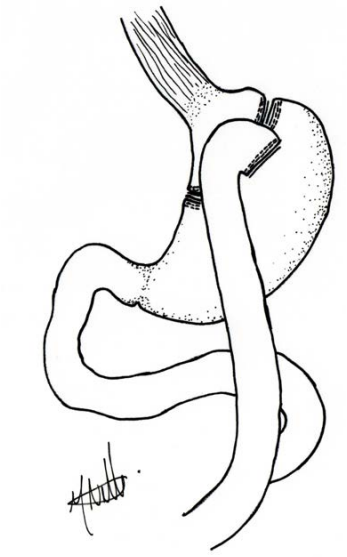

Figure 1. Roux-en-Y gastric bypass.

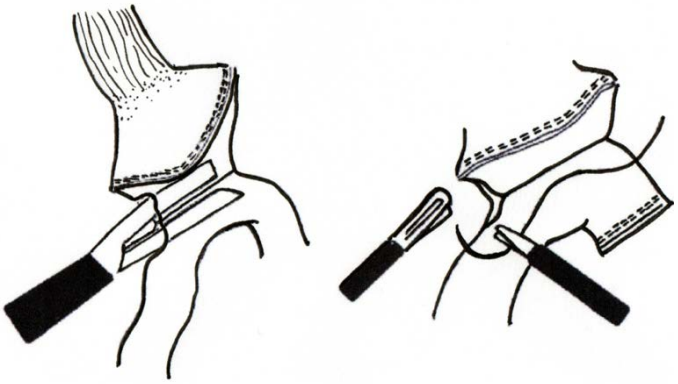

Figure 2. GE with linear stapler.

2.1.2. Circular

The gastric pouch was created using the same technique as the linear stapler, but for the GE a 25 mm circular stapler (Covidien® 25 mm Circular Stapler CEEA 25 mm) was used, where the stapler's anvil was inserted through a trans-oral delivery system (22 French caliber), and the stapler body was introduced through a small left laparotomy incision. Next, the alimentary limb was inserted through an enterotomy that was subsequently closed with a linear endostapler (**Figure 3**).

2.2. Classification of Complications

Among the complications studied, the following criteria were used for definition:

2.2.1. GE Stenosis

The most common symptoms, which led to the indication of diagnostic endoscopy in all cases in this study were: dysphagia associated with nausea and vomiting, starting after diet progression to solid foods.

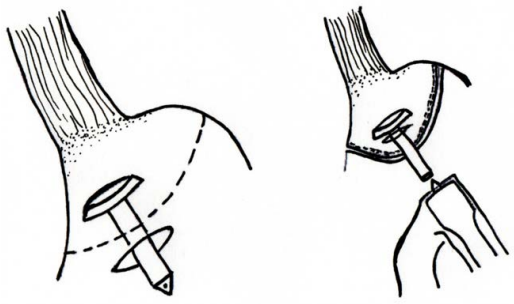

Figure 3. GE with circular stapler.

Post-LRYGB GE stenosis is classified by most authors with respect to onset time (acute or late), mechanism of formation (membrane, scarring or granuloma) and endoscopic appearance (mild, moderate, severe and total) [17].

The stenoses found in this study were classified by endoscopic appearance and graded as follows:

Grade I—Mild stenosis, allowing passage of a 10.5 mm endoscope.

Grade II—Moderate stenosis, allowing passage of a 8.5 mm endoscope.

Grade III—Severe stenosis, only possible to pass through with a guidewire.

Grade IV—Total or subtotal obstruction, being non-transposable.

2.2.2. GE Leak

Clinical and radiological criteria were used to identify a GE leak. As clinical criteria, tachycardia, epigastric pain, and fever in the recent postoperative period (<30 days) were the most common symptoms. Diagnostic was made by upper abdominal computed tomography and esophagogastroduodenoscopy with oral contrast.

2.2.3. Surgical Site Infection

Surgical site infection was identified by purulent discharge, pain, and local erythema in the first 30 days postoperatively.

2.2.4. Stapling Malfunction

Device malfunction (linear or circular stapler) was identified during the intraoperative period and was characterized by non-coaptation of the gastroenteroanastomosis edges, due to a technical failure of the device, leading to the need for hand-sewn anastomosis.

3. Statistical Analysis

Statistical assessment was performed by an independent statistician using SPSS, version 23. For the numerical variables, the descriptive values of median (1st and 3rd quartile) were presented. For the categorical variables, the descriptive values of frequency and percentage were presented. The Shapiro-Wilk test was applied to check whether the numerical variable has a normal distribution.

To check the association between two categorical variables, Pearson's chi-square test or Fisher's exact test was applied when the assumptions were not met. To

verify the association of the numerical variables, the Mann-Whitney test was applied. Finally, all analyses were performed at the 0.05 significance level.

4. Results

In the period studied, 457 patients underwent LRYGB, of these 241 had GE performed with a circular stapler (52.7%) and 216 with a linear stapler (47.3%). Both groups were evenly matched, and no significant differences were found regarding age, gender, initial BMI, and comorbidities. Table 1 summarizes the results found. The average loss of excess weight at 30 days was 22% in the CSA group and 21% in the LSA group, at 180 days it was 55% in the CSA group and 54.5% in the LSA group, and at 360 days it was 75% in the CSA group and 75% in the LSA group. In relation to postoperative complications that appeared during follow-up, four cases of GE stenosis were found (1.7%) in the CSA group and one case of stenosis (0.5%) in the LSA group ($p = 0.376$); five cases of surgical site infection (2.1%) in the CSA group and two cases (0.9%) in the LSA group ($p = 0.454$); one case of GE leak (0.4%) in the CSA group and no cases in the LSA group ($p = 1.0$); and one case of stapler malfunction (0.4%) in the CSA group and one case (0.5%) in the LSA group ($p = 1.0$).

The stenosis observed in both groups were classified by the same endoscopist, treated, and followed up in subsequent outpatient consultation. Of the 04 stenosis in the CSA group, three were classified as severe (grade III) and one as moderate (grade II). The mean time to diagnosis was 48 days for the 04 stenosis. All responded to a single endoscopic balloon dilatation and were of probable cicatricial origin. In the LSA group, the stenosis found was diagnosed 37 days after surgery, classified as severe (grade III) and treated with a single endoscopic dilatation, also of probable cicatricial origin.

The surgical site infections were successfully treated with drainage and antibiotic therapy in all cases. The only GE leak found in the CSA group was treated with CT-guided drainage and antibiotic therapy. Stapler malfunction was an intraoperative event in both groups and was corrected by manual suturing the entire anastomosis.

Table 1. Summary of results. The p-value for all variables was greater than 0.05, indicating no significant difference between the two groups for these variables.

	CSA	LSA
Average BMI	40.8 Kg/m^2	41.0 Kg/m^2
% Excess weight loss (30 days)	22%	21%
% Excess weight loss (180 days)	55%	54.5%
% Excess weight loss (1 year)	75%	75%
GE Stenosis	4 (1.7%)	1 (0.5%)
Surgical site infection	5 (2.1%)	2 (0.9%)
GE Leak	1 (0.4%)	0 (0%)
Stapler malfunction	1 (0.4%)	1 (0.5%)

5. Discussion

By analyzing the three main meta-analyses in the literature on the subject of this study, a preference for the linear-stapled anastomosis can be identified. The first one, published by Salvatore Giordano *et al.* [18] (2011), involved eight studies with a total of 1.321 patients and concluded that linear-stapled anastomosis led to a decreased risk of GE stenosis ($p = 0.04$), decreased risk of surgical site infection ($p = 0.0008$) and a shorter operative time ($p < 0.0001$). The second meta-analysis was published in 2012 by Marta Penna *et al.* [19], involving nine studies with a total of 9,374 patients, presenting primary and secondary outcomes. Among the primary outcomes (GE leak and stenosis), a decreased incidence of GE stenosis was found when the linear stapler was used ($p = 0.03$). As for the secondary outcomes (operative time, days of hospitalization, postoperative bleeding, surgical site infection, gastric ulcer, and loss of excess weight at one year), a decrease in operative time ($p < 0.0001$), postoperative bleeding ($p < 0.0001$), and weight loss at one year were found in the linear stapler group.

The third meta-analysis, published by David Edholm (2019) [20], involving 13 studies and 49,331 patients, showed that operative time was shorter in the linear stapler group ($p < 0.0001$). Twelve studies compared the appearance of GE leaks, with no significant difference between them. Eight studies evaluated surgical site infection, and it was a more common finding in the circular stapler group (RR 0.27 - 95% CI 0.21 - 0.33). GE stenosis was reported by 11 studies, and the RR of this anastomosis with linear stapler was 74% of the risk with circular stapler; however, there was overlap of the values, 95% CI (0.52 - 1.05), and no statistical difference in the risk of stenosis between the two techniques could be found.

The results of this study showed that, despite the high prevalence reported in the literature of the GE technique with linear stapler, there was no statistical significance in any of the variables investigated in relation to the two groups. Weight loss was similar in both groups, even though there was a difference in the size of the GE between the two techniques (25 mm in the CSA group and 30 mm in the LSA group). Despite the higher number of stenoses in the CSA group, these were not enough to infer a greater weight loss in the CSA group, a fact also observed in the long term (360 days postoperatively). It is relevant to point out that even studies comparing anastomoses with 21 mm *versus* 25 mm circular staplers have found no significant differences regarding weight loss [21]. The vast majority of studies that compared the loss of excess weight between GE types in LRYGB found similar results when there was a comparison for up to one year of follow-up, showing that this is a well-established outcome in the literature [22] [23].

Stenosis rates in LRYGB in the literature range from 4.3% to 8.8% with a circular stapler [12] [24] [25] and 0% to 7.3% with a linear stapler [22] [26] [27]. The four GE stenoses found in our study in the CSA group, as well as the one found in the LSA group, were all successfully treated with only one endoscopic balloon dilatation.

Among the possible reasons to explain a higher incidence of stenosis with a circular stapler, one of them would be the exact and immutable size of the anastomosis, whereas in anastomoses with linear staplers, this diameter can be a little larger, because there is not such a precision in the manufacturing for two reasons: there are no linear staplers of exact 25 mm available (they are usually adjusted through larger loads) and there is always the need to close the stapler entrance hole, the diameter of which may vary according to each surgeon's suture. It is also well-known that the causes are possibly multifactorial. Small undiagnosed GE leaks, staple line tension, local ischemia, and excessive exposure to hydrochloric acid are possible contributing factors to this outcome [28].

Surgical site infection is one of the most important outcomes and the most categorically accepted as a major disadvantage of the circular stapler technique, as most studies show a lower infection rate when the anastomosis is performed with a linear stapler [23]. In analyzing the three largest case series reporting this complication, we can make some relevant observations. The study by *Finks et al.* [29], with a total of 9904 patients undergoing three anastomosis techniques in LRYGB, shows that 276 patients (4.7%) developed surgical site infection in the circular stapler group, against 34 patients (1.6%) in the linear stapler group ($p < 0.0001$). However, this is a study based on an *online* survey, conducted by a US group called the *Michigan Bariatric Surgery Collaborative*, which included 44 surgeons from different services in the country. There is no detailed description of the surgical technique used by the services, nor do they mention standardization for inclusion in the study. There is also no detail about the surgeon's learning curve and the volume of surgeries in each service. The study by *Edholm et al.*, [30] with a total of 34,284 patients (33.169 in the linear group and 538 in the circular group), involving 43 Scandinavian centers, also an online survey with similar characteristics to the above mentioned study, compiled data from the *Scandinavian Obesity Registry—SOReg*, and showed that there were also more cases of infection in the circular group 6.9% versus 0.8% in the linear group ($p < 0.0001$).

The study by Bohdjalian *et al.* [23] was conducted at a single center, at the department of digestive surgery of the university of Vienna, with 150 patients undergoing anastomosis with linear and circular stapler (75 patients in each group), showing one (1.33%) site infection in the linear group and 10 (13.3%) in the circular group ($p = 0.002$). The technique employed in the circular-stapled anastomosis is well described and is the same performed in the service of origin of the patients in this case selection. However, there is no description of basic care related to the removal of the surgical specimen or routine drainage of the site where the anastomosis is performed.

In general, it is believed that surgical site infection is due to the fact that a slightly larger incision is required for the passage of the percutaneous circular stapler, as well as the need to remove an intestinal segment through the same incision, which would theoretically increase the risk of surgical site infection. In this study we also observed that there was no statistical difference between the

two groups in this regard, which can be attributed to three procedures routinely performed at the service of origin of the patients in this study. When the construction of the gastric pouch with the use of a circular stapler is employed, the removal of the surgical specimen is done by protecting it with a plastic bag. In addition, the subcutaneous tissue is washed with 2% chlorhexidine and a latex drain (*PenRose N*o. 2) is placed in the same incision. This latex drain is removed on the day of discharge, two days after surgery.

GE leak was found in only one patient in the CSA group (0.4%). The rates vary in the literature from 0% to 6.6% for circular-stapled anastomosis [12] [22] [25] and 0% to 5.5% for linear-stapled anastomosis [22] [26]. Apparently there is no study that shows any significant difference between the two techniques regarding the development of GE leaks, and this point is well accepted by most authors.

Stapler malfunction is not a variable commonly addressed in review articles on the subject; however, it can be considered a relevant complication and can directly interfere with the outcome of the procedure. It is known that laparoscopy mechanical devices malfunction can occur regardless of the manufacturer, and this study sought to evaluate whether this fact could influence the results of the two groups. One failure was found in each group, also showing no significant difference in this respect.

It is possible to assume that the learning curve in laparoscopic bariatric surgery was the determining factor for the results found in this study. According to Tinoco *et al.* [31], in a retrospective study with 2281 patients, it was identified that operative time, as well as complications in general, reduced significantly after a long learning curve of 500 patients undergoing LRYGB. It is possible that the systematization of the technique, as well as a trained staff, plus a long learning curve, make LRYGB a safe, practical, and feasible procedure. Therefore, when evaluating the results found in this study, it is suggested that there is no predilection for the anastomosis technique, and there is no practical relevance in this choice regarding the development of surgical complications and loss of excess weight, provided it is performed by a team experienced in laparoscopic bariatric surgery and with a long learning curve.

6. Conclusion

Both stapling techniques resulted in a similar loss of excess body weight during the follow-up period. Although the LSA group had fewer total complications, these were not statistically significant, which substantiates the fact that both techniques are safe and feasible, provided they are performed by a surgeon with experience in laparoscopic bariatric surgery.

Declaration

Ethical Approval and Consent

This study was entered in the Brazil platform and approved by the ethics and

research committee of Iguaçu University, campus V, under registration No. 23300719.0.0000.5288, and all methods were performed in accordance with the relevant guidelines and regulations (also include the Helsinki declaration).

Consent to Publish

All the authors consent with the publication.

Author's Contribution

All the authors contributed significantly, with supervision, data collection and review of the work.

Conflicts of Interest

No author has conflicts of interest.

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