



Surgical Management for Refractory Gastroparesis: First Comparative Case Series between Gastric Bypass and Pyloroplasty in Colombia

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Abstract

Gastroparesis is a common motor disorder of the upper gastrointestinal tract. Surgical management presents a challenge, particularly in regions lacking proprietary data or experience with surgical approaches to this condition. This study aimed to compare surgical outcomes of patients undergoing gastric bypass vs. pyloroplasty for refractory gastroparesis, for the first time in Colombia. A longitudinal study was conducted on 16 patients with refractory gastroparesis undergoing pyloroplasty or laparoscopic gastric bypass at a tertiary referral center in Colombia between January 2018 and December 2020. Ten (62.5%) patients underwent gastric bypass, and 93.8% were women. Surgical time was significantly shorter with pyloroplasty ($p=0.001$), as well as time to symptom resolution (50% vs. 30% within the first 24 h, and 100% vs. 70% at 15 days). The preoperative and postoperative mean body mass index (BMI) was 29.7 (21.3—33.4) and 23.1 (20.9—25.4), respectively. Both groups were similar in all analyzed characteristics except for a higher BMI in the gastric bypass group ($p=0.01$). Gastric bypass resulted in a reduction of approximately 20% of the baseline BMI value, compared to 5% with pyloroplasty. This study found that both techniques were feasible and safe for surgical treatment of refractory gastroparesis. Gastric bypass may be preferred for obese patients due to greater weight loss, which could impact additional outcomes.

Keywords Gastroparesis · Gastric bypass · Comparative study · Treatment outcome · Operative surgical procedures

Introduction

Gastroparesis (GP) is a chronic motility disorder that affects a considerable portion of the population and causes significant debilitation [1]. The prevalence of GP is higher in women, with rates of 37.8/100,000 compared to 9.6/100,000 in men [2]. Diagnosis of GP involves objective evidence of delayed gastric emptying, usually through a four-hour solid gastric phase scintigraphy [3]. Due to controversies

surrounding various surgical approaches for this pathology, the management of GP poses a challenge for surgeons [3, 4]. Furthermore, GP incurs substantial financial burden on the healthcare system, emphasizing the importance of its effective management [5]. The impact of GP on patients' quality of life is significant, as it impairs physical and social functioning [5]. Optimal outcomes require a multidisciplinary approach to GP management.

Managing GP requires a comprehensive approach that considers not only the medical aspects of the disorder, but also the social and psychological factors [3, 4]. Patients with GP frequently experience a significant reduction in their quality of life, as they may struggle to maintain employment, participate in social activities, and enjoy their favorite foods [6]. Effective management of GP may involve a combination of medical, dietary, and lifestyle changes, such as changes in eating habits, medications to improve gastric motility, and psychological support to address the emotional impact of the condition [7]. In some cases, surgery may be recommended as a treatment option, although research on the various

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surgical approaches for GP is limited, and the long-term outcomes are not well understood [7].

In Colombia and Latin America, there is very limited evidence related to the surgical management of gastroparesis, and the associated techniques used are poorly understood or non-existent in some countries. Given that surgical intervention may be the only solution for refractory gastroparesis, it is crucial to have sufficient evidence to bridge the current knowledge gap. The aim of this study was to compare the surgical outcomes of patients undergoing either gastric bypass or pyloroplasty for refractory gastroparesis for the first time in Colombia.

Patients and Methods

Study Design and Study Population

Longitudinal retrospective study at a tertiary referral center in Colombia, comparing the surgical outcomes of adult patients (over 18 years of age) diagnosed with refractory gastroparesis who underwent pyloroplasty or laparoscopic gastric bypass between January 2018 and December 2020. To be included, patients had to have a complete record and meet the criteria for refractory gastroparesis defined by the American Gastroenterology Association (AGA), which includes persistent symptoms in the context of objectively confirmed gastric emptying delay, despite the use of dietary adjustment and metoclopramide as a first-line therapeutic agent [8]. Laparoscopic gastric bypass was used for patients with a body mass index (BMI) ≥ 35 kg/m², while pyloroplasty was used for those with a BMI < 35 kg/m².

We excluded patients who had previously undergone surgery for their refractory gastroparesis, those with gastroparesis caused by intra-abdominal diseases such as pancreatitis, and those with severe malnutrition. Diagnosis of gastroparesis was confirmed by gastric scintigraphy, which showed 10% or more of the gastric volume remaining in the stomach after 4 h. Surgical intervention was considered after 3 months of third-line treatment with no symptom relief. The surgeries were performed by two senior surgeons with over 20 years of experience and a fellowship in minimally invasive laparoscopic surgery.

Data Collection

The study data was collected from the institutional database, and the researchers reviewed the medical records to obtain information on sociodemographic, clinical, preoperative, perioperative, and postoperative variables. Patients' postoperative BMI was measured at 1 month, 3 months, 6 months, and 1 year. All patients underwent pre-surgical screening and were diagnosed with or ruled out for diabetes, autoimmune

diseases, cancer, and peptic ulcer disease. Patients with no determined cause for their gastroparesis were categorized as having an idiopathic cause. The follow-up was performed longitudinally based on clinical data only. The volume of bleeding was calculated using the amount of laparoscopic suctioning collected during the procedures.

Surgical Technique Description

For the laparoscopic Roux-en-Y gastric bypass, the surgeon utilized five laparoscopic ports. The gastric pouch, which had a volume of 60–75 cc, was created using a 60 mm green endostapler. The staple line was reinforced using 2–0 polidioxanone suture. A gastro-jejunal anastomosis was created 80 cm distal to the Treitz angle with the use of a 60 mm green endostapler and polidioxanone 2–0 suture. To create a Roux-en-Y configuration, 50 cm of alimentary loop were measured to make a side-to-side jejuno-jejunal anastomosis with a 60 mm green endostapler. The surgeon closed the peritoneal defects with 2–0 polyglactin suture to prevent internal hernias. Before concluding the surgery, a methylene blue test was performed.

For the pyloroplasty surgical technique, the surgeon also utilized five laparoscopic ports. Using a laparoscopic ultrasonic scalpel, the surgeon made an anterior longitudinal antro-pyloro-duodenal incision measuring 4–6 cm along the axis of the digestive tract. The Heineke-Mikulicz technique was employed, and 2–0 polyglactin suture was used to suture the tissue in an anti-axial way to complete the pyloroplasty. In both procedures, the abdominal wall was closed using polyglactin 1–0 suture, and the skin was closed with 3–0 polypropylene suture.

Statistical Analysis

The normality of quantitative variables was tested using the Kolmogorov–Smirnov test. Data were presented as mean \pm standard deviation (SD) for continuous variables. Qualitative variables were summarized using frequency and percentages. Comparative analysis was carried out using Pearson's Chi-square test or Fisher's exact test for categorical variables and Student t test or Mann–Whitney for quantitative variables. A $p < 0.05$ was considered significant in all cases. Data were recorded in a Microsoft Excel digital spreadsheet. Subsequently, the data were exported to IBM SPSS (Chicago, IL) version 25 statistical software, where the analysis was performed.

Ethical Statements

This study was approved by the institution ethics review board. The protocol was implemented in accordance with the Declaration of Helsinki [9] and Good Clinical Practice

guidelines [10]. The ethics committee exempted the collection of informed consent, due to the retrospective nature of the study and the minimal risk.

Results

The study included 16 patients, of whom 10 (62.5%) underwent gastric bypass. Among these patients, 93.8% ($n = 15$) were women, with a mean age of 45.1 (± 11.4) years. The average preoperative and postoperative BMI were 29.7 kg/m² (21.3–33.4) and 23.1 kg/m² (20.9–25.4), respectively. Idiopathic gastroparesis was present in 14 (87.5%) patients (The remaining two had diabetic gastroparesis), most of whom had a BMI within the normal range (20–25), followed by grade 1 obesity (31–36). Comorbidities included obesity ($n = 5$, 31.3%) and hypertension ($n = 4$, 25%). The most frequent symptoms before surgery were nausea/reflux ($n = 8$, 50%) followed by vomiting ($n = 2$, 12.5%). Gastroparesis was diagnosed in all cases (100%) using gastric emptying scintigraphy (Table 1).

Upon comparing the different characteristics between the groups, a reduction of approximately 20% of the baseline BMI value was observed with gastric bypass, in contrast to 5% with pyloroplasty. The time taken for symptom resolution was found to be significantly shorter with the pyloroplasty technique, with 50% vs. 30% in the first 24 h, and 100% vs. 70% at 15 days (Table 2). Nausea/reflux was the symptom that required the longest time for resolution. The mean surgical time for the bypass group was 52 ± 5.3 min, whereas it was 38 ± 2.4 min ($p = 0.001$) for the pyloroplasty group. Moreover, the mean intraoperative bleeding for the bypass group was 22 ± 6.3 cc, whereas it was 15.8 ± 4.9 cc ($p = 0.05$) for the pyloroplasty group. Overall, both procedures showed similar behaviors in terms of intraoperative and postoperative results (Table 3). Notably, the patients who underwent gastric bypass had higher BMIs (were more obese) ($p = 0.01$) and had a longer operative time compared to patients in the pyloroplasty group.

Discussion

Functional dyspepsia and gastroparesis, the two most common neuromotor disorders of the upper gastrointestinal tract, are characterized by symptoms such as nausea, reflux, vomiting, and abdominal distension. Gastroparesis, a chronic condition, is associated with delayed gastric emptying, but without any mechanical obstruction [3]. In the initial stages, a multidisciplinary approach involving diet, lifestyle changes, pharmacological measures, and, if necessary, parenteral nutrition is employed for the management of gastroparesis [11]. Surgical intervention is considered as

Table 1 Sociodemographic and clinical characteristics of study population

Variable	N = 16 n (%)
Sex	
Female	15 (93.75%)
Male	1 (6.25%)
Age, mean (SD)	45.18 (11.45)
BMI, mean (SD)	
Preoperative	27.94 (6.43)
Postoperative	23.16 (2.36)
Preoperative diagnosis	
Diabetic gastroparesis	2 (12.5%)
Idiopathic gastroparesis	14 (87.5%)
Comorbidities	
Obesity	5 (31.25%)
Arterial hypertension	4 (25%)
Diabetes mellitus	2 (12.5%)
Hypothyroidism	2 (12.5%)
Gastroesophageal reflux	1 (6.25%)
Main symptom	
Nausea/Reflux	8 (50%)
Vomit	2 (12.5%)
Bloating	2 (12.5%)
Abdominal distention	2 (12.5%)
Abdominal pain	2 (12.5%)
Procedure	
Gastric bypass	10 (62.5%)
Pyloroplasty	6 (37.5%)
Diagnostic study	
Gastric emptying gammagraphy	16 (100%)

*BMI Body Mass Index; SD Standard Deviation

a treatment option only when initial medical therapy proves ineffective, contingent upon the patient's response [11]. Multiple factors can contribute to the development of gastroparesis, including extrinsic neurological control diseases like Parkinson's, amyloidosis, and paraneoplastic disease, as well as disorders that cause infiltration or degeneration of the stomach's muscular layer, such as scleroderma [12]. Among our population, idiopathic gastroparesis accounted for the majority of cases ($n = 14$; 87.5%).

The objectives of treatment for gastroparesis (GP) encompass the correction of nutritional deficiencies, alleviation of symptoms, and identification of the underlying cause [13]. Achieving effective management requires a combination of medical and surgical approaches [14]. Surgical management has gained interest due to the limited success rate and high rate of conservative treatment failure, although it poses challenges due to the patient population and results from case series [15]. Surgical options for patients with refractory GP

Table 2 Comparison of clinical, perioperative and postoperative variables, according to the surgical technique used

Variable	Bypass	Pyloroplasty
	N=10	N=6
	n (%)	
Preoperative diagnosis		
Diabetic Gastroparesis	2 (20)	0 (0)
Idiopathic gastroparesis	8 (80)	6 (100)
Comorbidities		
Obesity	5 (50)	0 (0)
Arterial hypertension	3 (30)	1 (16.6)
Diabetes mellitus	2 (20)	0 (0)
Hypothyroidism	1 (10)	1 (16.6)
Gastroesophageal reflux	1 (10)	0 (0)
Surgical time (minutes), mean (SD)	52 (5.3)	38 (2.4)
Blood loss (cc), mean (SD)	22 (6.3)	15.83 (4.9)
Re-intervention	0 (0)	0 (0)
Postoperative complications	0 (0)	0 (0)
Hospital stay time (days), mean (SD)	2 (0)	2 (0)
Postoperative time to improve symptoms		
< 24 h	3 (30)	3 (50)
8 days	2 (20)	2 (33.3)
15 days	2 (20)	1 (16.7)
30 days	3 (30)	0 (0)

*CC Cubic centimeter; SD Standard Deviation

Table 3 Comparison of frequency of comorbidities, weight reduction, perioperative variables and time of symptom resolution, according to the technique used

Variable	Bypass	Pyloroplasty	p-value
	N=10	N=6	
	n (%)		
Age (years), mean (SD)	46.8 (9.2)	42.5 (15)	> 0.05
Preoperative BMI, mean (SD)	30.86 (6.1)	23.06 (3.2)	0.01
Postoperative BMI, mean (SD)	23.65 (2.7)	22.35 (1.4)	> 0.05
Obesity	5 (50)	0 (0)	0.01
Arterial hypertension	3 (30)	1 (16.7)	0.05
Diabetes mellitus	2 (20)	0 (0)	> 0.05
Hypothyroidism	1 (10)	1 (16.7)	> 0.05
Gastroesophageal reflux	1 (10)	0 (0)	> 0.05
Surgical time, mean (SD)	52 (5.4)	38 (2.4)	0.001
Bleeding, mean (SD)	22 (6.3)	15.83 (4.9)	0.05
Symptom improvement on the 8th day	5 (50)	5 (83.3)	0.02

*SD Standard Deviation

include pyloroplasty, subtotal or total gastrectomy, and gastric electrical stimulation [3, 4, 16]. In cases where total parenteral nutrition is administered, enteral feeding should

be prioritized to mitigate potential complications such as infection, limited vascular access, and thrombosis [14].

Studies consisting of case series and small retrospective analyses have reported on the benefits of surgical intervention for managing refractory GP, including procedures such as pyloroplasty, jejunostomy, and total or subtotal gastrectomy [17]. Nevertheless, the controversy around surgical management stems from the high failure rates associated with these procedures [16, 18]. Although pyloroplasty has been shown to enhance gastric emptying, it is rarely used as the primary treatment for GP [15]. Several studies have reported symptom resolution in up to 90% of patients, but there have also been reports of complications such as dumping syndrome [19, 20]. Total or subtotal gastrectomy is typically considered as a treatment option for patients who have undergone previous unsuccessful surgical procedures and has a high success rate [21].

Carefully selected patients who have failed other conservative treatment options can benefit from surgical techniques that alter gastric anatomy [22]. In a retrospective analysis of 50 patients with refractory GP of unspecified etiology who underwent laparoscopic pyloroplasty, a significant improvement in postoperative symptoms ($p < 0.001$) and gastric emptying ($p < 0.001$) was observed at three months follow-up [19]. Total and subtotal gastrectomy appears to be more effective in patients with postoperative GP associated with damage or section of the vagus nerve [3]. Although methods such as pyloroplasty and gastric stimulator implantation have a high failure rate, they may still be considered as the first line of surgical management due to the short time of symptom resolution and low complication rate. If these methods fail, more invasive procedures such as total or subtotal gastrectomy may be required [19].

Idiopathic, diabetic, and postoperative GP are the most common forms of the disorder. Previous studies have reported that idiopathic GP accounts for approximately 35% of all patients, while diabetic GP accounts for 29%, and postoperative GP for 36% [15, 23]. In the present case series, idiopathic GP was the most frequently identified form of GP, excluding postoperative GP presentation as a surgical history exclusion criterion.

Most patients with gastroparesis experience characteristic symptoms such as nausea, reflux, vomiting, early satiety, and weight loss. However, abdominal pain is often overlooked as a symptom of gastroparesis. In a multi-center study conducted by a national institute of health consortium, it was found that 72% of patients with gastroparesis experienced abdominal pain, while Zehetner et al. [24] reported that nausea and vomiting were the predominant symptoms in 90% and 84% of patients, respectively. A study on gastrectomy for the management of gastroparesis, with results similar to those of the present study, found that 50% of patients reported nausea/reflux as the primary symptom [12].

Scintigraphy is the standard diagnostic test for gastroparesis used to measure gastric emptying. In the present series, all 16 patients were diagnosed based on a gastric emptying scan report.

In a retrospective series published by Papasavas et al. [25], seven morbidly obese patients (BMI = 39.5) with idiopathic or diabetic gastroparesis demonstrated marked symptom improvement after Roux-en-Y gastric bypass, with total symptom scores significantly decreased. Prolonged treatment with anti-nausea medications was required in the postoperative period for three patients, and two patients required readmissions due to dysphagia, nausea, and anastomotic ulcer. Recently, Masclee et al. [26] conducted a systematic review to evaluate the efficacy and safety of sleeve gastrectomy and Roux-en-Y gastric bypass surgery in patients with refractory gastroparesis. Nineteen studies with a total of 222 refractory gastroparesis patients (147 Roux-en-Y gastric bypass, 39 sleeve gastrectomy, and 36 subtotal gastrectomy) were included. All studies reported postoperative symptom improvement, particularly vomiting and nausea. Gastric emptying improved postoperatively in 45% to 67% of patients who underwent sleeve gastrectomy and 87% of those who underwent Roux-en-Y gastric bypass. The findings suggest that this technique could be a viable option for achieving symptom resolution, as well as promoting weight loss in patients who are obese and have comorbidities related to metabolic disorders.

Pyloroplasty has been demonstrated to improve gastric emptying, but it is not commonly used as a primary treatment for gastroparesis [15]. Some case series have reported symptoms resolution in up to 89% of patients [19, 20]. According to Shada et al. [15], pyloroplasty as a primary treatment is associated with a persistence of delayed gastric emptying after the procedure of 22%, and an increased risk of nausea and abdominal pain of 20% [20]. An electric gastric stimulator has been reported to achieve improvement in up to 63% of patients by Zehetner et al. [24], while 87% of patients who underwent gastrectomy reported significant improvement in nausea, vomiting, and epigastric pain [18]. However, up to 26% of patients experienced a lack of response or malfunction of the stimulator and required a laparoscopic subtotal gastrectomy, which resulted in 100% improvement of symptoms. Mason et al. [25] have proposed laparoscopic gastrectomy as the preferred first-line therapy for the surgical treatment of GP due to its success. In the present series of patients who underwent gastric bypass and pyloroplasty, immediate improvement of symptoms was observed in 30% and 50% of cases, respectively. The pyloroplasty group had a faster response rate, with up to 30% of patients who underwent bypass experiencing improvement up to 30 days after the surgical procedure.

This suggests that pyloroplasty may be a valuable treatment option, particularly for patients who require a faster response rate, and gastric bypass may be a useful option for those who require weight loss intervention.

Postoperative complications observed in our study were primarily associated with patients' comorbidities, rather than the surgical procedure itself. Consistent with the findings reported by Zehetner et al. [24], we observed no leaks, postoperative bleeding, or wound dehiscence. The length of hospital stay in our patients was comparable to that reported in the literature [26]. Our results indicate that both pyloroplasty and laparoscopic gastric bypass are safe treatments for refractory GP, with comparable outcomes in symptom resolution and associated morbidity.

Strengths and Limitations

The limitations of this study should be noted, including its retrospective design, small sample size, and reliance on subjective symptom assessment. However, it is important to highlight that this is the first study of its kind in Colombia and one of the few in Latin America, providing valuable evidence on the outcomes of these two surgical techniques for refractory gastroparesis in a middle-income country with limited access to expensive specialized therapies. This study provides a foundation for further research aimed at addressing specific issues.

Conclusions

This study indicates that both surgical techniques were viable and secure options for treating refractory gastroparesis. Gastric bypass may be preferable for obese patients, as it promotes greater weight loss that could have ancillary benefits. On the other hand, pyloroplasty may be a more viable choice for high-risk patients with time constraints. Both procedures successfully resolved all symptoms within 30 days. It should be noted, however, that further research is necessary to validate these findings and to identify optimal treatment strategies for this condition.

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Data Availability All data used in this study can be found in the manuscript.

Declarations

Conflict of Interest The authors declare that there is no conflict of interest.

References

1. Vavricka SR, Greuter T (2019) Gastroparesis and dumping syndrome: current concepts and management. *JCM* 8:1127. <https://doi.org/10.3390/jcm8081127>
2. Jung H, Choung RS, Locke GR et al (2009) The incidence, prevalence, and outcomes of patients with gastroparesis in Olmsted county, Minnesota, from 1996 to 2006. *Gastroenterology* 136:1225–1233. <https://doi.org/10.1053/j.gastro.2008.12.047>
3. Stein B, Everhart KK, Lacy BE (2015) Gastroparesis: a review of current diagnosis and treatment options. *J Clin Gastroenterol* 49:550–558. <https://doi.org/10.1097/MCG.0000000000000320>
4. Lacy BE, Crowell MD, Mathis C et al (2018) Gastroparesis: quality of life and health care utilization. *J Clin Gastroenterol* 52:20–24. <https://doi.org/10.1097/MCG.0000000000000728>
5. Egboh S-MC, Abere S (2022) Gastroparesis: a multidisciplinary approach to management. *Cureus* 14:e21295. <https://doi.org/10.7759/cureus.21295>
6. Fosso CL, Quigley EMM (2018) A critical review of the current clinical landscape of gastroparesis. *Gastroenterol Hepatol (N Y)* 14:140–145
7. Petrov RV, Bakhos CT, Abbas AE et al (2020) Endoscopic and surgical treatments for gastroparesis. *Gastroenterol Clin North Am* 49:539–556. <https://doi.org/10.1016/j.gtc.2020.04.008>
8. Lacy BE, Tack J, Gyawali CP (2022) AGA clinical practice update on management of medically refractory gastroparesis: expert review. *Clin Gastroenterol Hepatol* 20(3):491–500. <https://doi.org/10.1016/j.cgh.2021.10.038>
9. (2013) World Medical Association Declaration of Helsinki: Ethical Principles for Medical Research Involving Human Subjects. *JAMA* 310:2191. <https://doi.org/10.1001/jama.2013.281053>
10. Good Clinical Practice Network (2023) Good Clinical Practice. Available in: <https://gcp.network/es/#>. Accessed 23 Apr 2023
11. Zheng T, Camilleri M (2021) Management of gastroparesis. *Gastroenterol Hepatol (N Y)* 17:515–525
12. Camilleri M, Parkman HP, Shafi MA et al (2013) Clinical guideline: management of gastroparesis. *Am J Gastroenterol* 108:18–37. <https://doi.org/10.1038/ajg.2012.373>. (quiz 38)
13. Reddivari AKR, Mehta P (2022) Gastroparesis. In: StatPearls. StatPearls Publishing, Treasure Island (FL). Available from: <https://www.ncbi.nlm.nih.gov/books/NBK551528/>. Accessed 23 Apr 2023
14. Liu N, Abell T (2017) Gastroparesis updates on pathogenesis and management. *Gut Liver* 11:579–589. <https://doi.org/10.5009/gnl16336>
15. Shada AL, Dunst CM, Pescarus R et al (2016) Laparoscopic pyloroplasty is a safe and effective first-line surgical therapy for refractory gastroparesis. *Surg Endosc* 30:1326–1332. <https://doi.org/10.1007/s00464-015-4385-5>
16. Sun Z, Rodriguez J, McMichael J et al (2015) Surgical treatment of medically refractory gastroparesis in the morbidly obese. *Surg Endosc* 29:2683–2689. <https://doi.org/10.1007/s00464-014-3990-z>
17. Jones MP, Maganti K (2003) A systematic review of surgical therapy for gastroparesis. *Am J Gastroenterol* 98:2122–2129. <https://doi.org/10.1111/j.1572-0241.2003.07721.x>
18. Sarosiek I, Davis B, Eichler E, McCallum RW (2015) Surgical approaches to treatment of gastroparesis. *Gastroenterol Clin North Am* 44:151–167. <https://doi.org/10.1016/j.gtc.2014.11.012>
19. Landreneau JP, Strong AT, El-Hayek K et al (2019) Laparoscopic pyloroplasty versus endoscopic per-oral pyloromyotomy for the treatment of gastroparesis. *Surg Endosc* 33:773–781. <https://doi.org/10.1007/s00464-018-6342-6>
20. Toro JP, Lytle NW, Patel AD et al (2014) Efficacy of laparoscopic pyloroplasty for the treatment of gastroparesis. *J Am Coll Surg* 218:652–660. <https://doi.org/10.1016/j.jamcollsurg.2013.12.024>
21. Borrazzo EC (2013) Surgical management of gastroparesis: gastrostomy/jejunostomy tubes, gastrectomy, pyloroplasty, gastric electrical stimulation. *J Gastrointest Surg* 17:1559–1561. <https://doi.org/10.1007/s11605-013-2255-9>
22. Acquafresca PA, Palermo M, Rogula T et al (2015) Early surgical complications after gastric by-pass: a literature review. *ABCD, arq bras cir dig* 28:74–80. <https://doi.org/10.1590/s0102-67202015000100019>
23. Nguyen LA, Snape WJ (2015) Clinical presentation and pathophysiology of gastroparesis. *Gastroenterol Clin North Am* 44:21–30. <https://doi.org/10.1016/j.gtc.2014.11.003>
24. Zehetner J, Ravari F, Ayazi S et al (2013) Minimally invasive surgical approach for the treatment of gastroparesis. *Surg Endosc* 27:61–66. <https://doi.org/10.1007/s00464-012-2407-0>
25. Mason RJ (2005) Gastric electrical stimulation: an alternative surgical therapy for patients with gastroparesis. *Arch Surg* 140:841. <https://doi.org/10.1001/archsurg.140.9.841>
26. Shahsavari D, Zhao H, Ehrlich AC et al (2020) Factors associated with hospital admissions and readmissions in patients with gastroparesis using the nationwide readmission database. *J Clin Gastroenterol* 54:801–805. <https://doi.org/10.1097/MCG.0000000000001295>

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