

Systematic review on sleeve gastrectomy or Roux-en-Y gastric bypass surgery for refractory gastroparesis

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Review article

Systematic review on sleeve gastrectomy or Roux-en-Y gastric bypass surgery for refractory gastroparesis

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Abstract

Management of refractory gastroparesis is challenging after diet, prokinetics, and long-term nutritional support have failed. In this review, the efficacy and safety of surgical interventions (sleeve gastrectomy and Roux-en-Y gastric bypass surgery) are evaluated systematically in patients with refractory gastroparesis. The PubMed, Embase, and Scopus databases were searched to identify relevant studies published up to June 2021. Outcome of interest was symptom improvement and gastric emptying. Nineteen studies with 222 refractory gastroparesis patients (147 Roux-en-Y gastric bypass, 39 sleeve gastrectomy, and 36 subtotal gastrectomy) were included. All studies reported symptom improvement postoperatively, particularly vomiting and nausea. Gastric emptying improved postoperatively in 45% up to 67% for sleeve gastrectomy and 87% for Roux-en-Y gastric bypass. The findings of our systematic review suggest that sleeve gastrectomy and Roux-en-Y gastric bypass surgery improve symptoms and gastric emptying in patients with refractory gastroparesis. Surgery may be effective as treatment for a small group of patients when all other therapies have failed. (Surg Obes Relat Dis 2022; ■:1–12.) © 2022 American Society for Metabolic and Bariatric Surgery. Published by Elsevier Inc. All rights reserved.

Keywords:

Gastroparesis; Sleeve gastrectomy; Roux-en-Y gastric bypass surgery; Refractory gastroparesis

Gastroparesis is a disorder of gastric motility and consists of symptoms such as nausea, vomiting, epigastric pain, and weight loss [1]. Diagnosis of gastroparesis is based on clinical symptoms, delayed gastric emptying on a 4-hour gastric emptying study, and a normal gastroduodenoscopy thereby

excluding mechanical obstruction as diagnosis. Causes of gastroparesis can be divided in 4 groups: postoperative, diabetic, postinfectious, and idiopathic. Although the pathophysiology of gastroparesis is not fully understood, several mechanisms have been suggested, such as diminished gastric motility, impaired gastric accommodation, and pyloric dysfunction [2,3]. Management of gastroparesis focuses on decreasing symptoms and improving nutritional status. Conventional therapy includes dietary advice with nutritional support, use of antiemetics or prokinetics, and when these are not effective, a period of gastric rest with short- or longer-term enteral nutrition [4]. If these therapies are not successful, gastric electrical

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stimulation (GES) by gastric pacemaker and pyloric interventions such as pyloroplasty and pyloromyotomy (either laparoscopic, open, or gastric peroral endoscopic myotomy [G-POEM]) have been introduced in recent years as treatment options for refractory gastroparesis [5–9]. Several systematic reviews report promising results on the efficacy of G-POEM [5,6]. However, a small proportion of patients with refractory gastroparesis does not improve and may develop a decompensated stomach. For these patients, it has been suggested previously that partial gastrectomy may be effective as optional therapy in refractory gastroparesis [10]. From surgical therapies applied in patients with obesity, we have learned that both sleeve gastrectomy and gastric bypass surgery accelerate gastric emptying time and small bowel transit [11–14]. Proposed mechanisms include a change in gastric distensibility by reducing gastric volume and altered contractility by resetting the gastric pacemaker. Since 2013, several case studies reported on single-center efficacy of gastric surgery in refractory gastroparesis [13,15–29]. Up to the present, randomized studies on the overall efficacy and safety of surgery for gastroparesis are lacking. Therefore, the aim of our systematic review was to assess efficacy on symptom improvement and gastric emptying of gastric sleeve and Roux-en-Y gastric bypass surgery in patients with refractory gastroparesis.

Methods

Protocol

This systematic review was performed in accordance with the Preferred Reporting Items for Systematic Reviews and Meta-Analysis (PRISMA) [30] and the *Cochrane Handbook for Systematic Reviews* [31] guidelines. The protocol was submitted to the International Prospective Register of Systematic Reviews (PROSPERO) website [32].

Literature search and study selection

A comprehensive literature search was developed by an experienced medical reference librarian and subsequently executed in Embase, PubMed, and Scopus through June 24, 2021, with an updated search through April 21, 2022, in order to include all the most recent relevant articles. The following search terms were used in various combinations: “gastroparesis,” “gastric emptying,” “gastric stasis,” “gastric motility,” “gastric atony,” “gastric sleeve,” “sleeve gastrectomy,” “partial or subtotal or near-total gastrectomy,” and “gastric bypass or Roux-en-Y bypass.” All identified records were screened based on their title and abstract, and eligible articles were further evaluated on full-text level by 2 independent investigators (G.M., A.M.). Only articles written in the English language were included. Additionally, references of eligible articles were reviewed to identify other relevant studies. Conference abstracts with detailed information on the outcome of interest also were eligible for

inclusion in the review, if not published already in another full-text article.

Eligibility criteria

All study designs were eligible for inclusion in the systematic review (i.e., randomized clinical trials, observational studies, and case reports). Studies had to include patients 15 years of age or older with a diagnosis of gastroparesis. Interventions of interest included sleeve gastrectomy and partial or subtotal gastrectomy with Roux-en-Y bypass. Indication for the intervention should be gastroparesis, but co-morbid conditions such as hiatus hernia, obesity, and reflux were allowed. Exclusion criteria were prior gastric surgery (e.g., Billroth I or II), malignancy, and any other benign indication for gastric sleeve or Roux-en-Y gastric bypass surgery, such as morbid obesity as the sole indication for surgery (e.g., studies with patients with obesity without a diagnosis or documentation of gastroparesis but only with a bariatric indication for surgery were excluded). Two independent investigators (G.M., A.M.) reviewed retrieved abstracts and discussed discrepancies before full-text review and before data collection were performed. Any discrepancy between investigators was discussed until consensus was reached.

Data collection

Data collection was performed by 2 independent investigators (G.M., A.M.) from included articles using a pre-designed extraction data form. Variables that were extracted included study design, year of publication, number of patients, patient age, co-morbid diseases, weight or body mass index (BMI), type of intervention, gastric emptying time before and after intervention, etiology of gastroparesis, clinical success, symptoms before and after intervention, length of procedure, postoperative complications, readmission, and duration of follow-up. If available, symptom scores on severity of symptoms such as the Gastroparesis Cardinal Symptom Index (GCSI) and the Patient Assessment of Upper Gastrointestinal Disorders–Symptom Severity Index (PAGI-SYM) were extracted. Quality of included studies was assessed using the National Institutes of Health (NIH) quality assessment tool for case series [33].

Data synthesis and statistical analysis

Efficacy in terms of symptom improvement and gastric emptying rates were considered as primary outcomes of interest per type of intervention separately. Because of differences in availability symptom scoring systems and pre- and postoperative emptying rates in the included studies, it was decided to report original results and weighted averages according to the number of patients in the separate studies. Percentage changes in emptying times and GCSI scores postoperatively were calculated as (postoperative score – preoperative score)/preoperative score.

Results

Study selection

The search strategy identified 2751 publications, of which 739 were removed as duplicate records, and thus 2012 records were screened by title and abstract. A total of 75 articles were assessed by full text, of which 56 were excluded for various reasons (Fig. 1). Finally, 19 studies were included in this systematic review, including a total of 222 patients with gastroparesis, of whom 147 patients received Roux-en-Y gastric bypass surgery, reported in 12 studies [17–21,25–29,34,35]; 39 patients underwent sleeve gastrectomy, reported in 5 studies [13,15,16,23,36]; and 36 patients underwent subtotal or near-total gastrectomy, reported in 2 studies [24,37] (Table 1). Eighteen studies were full-text articles, and 1 study was a conference abstract [36].

Study characteristics and quality assessment

Study characteristics are shown in Table 1. In total, 5 studies were included with gastric sleeve as intervention, 12 studies included Roux-en-Y gastric bypass, of which 1

study reported separate results on gastric bypass with stomach left in situ and gastric bypass with subtotal gastrectomy. Finally, 2 studies reported on subtotal gastrectomy as intervention. Seven studies were case reports [13,15,18,19,25,36,37], and 12 studies were retrospective observational studies [16,17,20,21,23,24,26–29,34,35]. Based on NIH quality assessment, 4 studies had good quality, and the other 15 studies were of fair quality (Table 2). Follow-up time for patients in this review varied between a minimum of 3 months and up to 8.5 years maximum. Duration of the surgical procedure was reported in only 5 studies including Roux-en-Y gastric bypass surgery and varied between 144 and 223 minutes (Table 1). The definition of refractory gastroparesis in the studies was at least based on symptoms and a gastric emptying test in 18 studies, of which 7 also required gastroduodenoscopy, barium meal examination, esophageal manometry, or pH/impedance studies (Supplementary Table 1). One study relied on symptoms only for the diagnosis of gastroparesis. The etiology of gastroparesis in 74 patients was postoperative, idiopathic in 61, and of diabetic origin in 66 and was not reported for 21 patients. Changes in BMI from preoperatively to

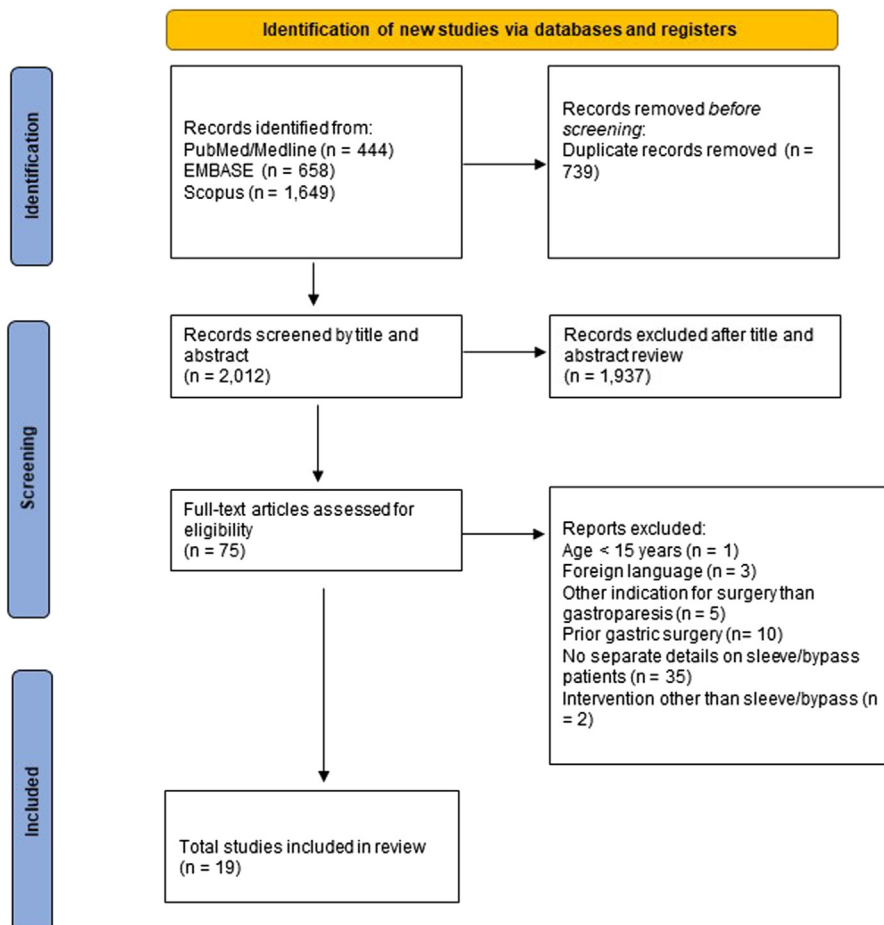


Fig. 1. Search strategy and study selection flowchart.

Table 1
Demographics and characteristics from included studies

Study	Type of intervention	Study design	Study period	Number of patients	Age (yr), median (IQR) or mean \pm SD	Sex (female:male)	Etiology of gastroparesis			Procedure time (min), median (IQR) or mean \pm SD	Follow-up (mo), median (IQR) or mean \pm SD	Hospital stay (d), median (IQR) or mean \pm SD	Postoperative complications, n (%)	Readmission, n (%)
							Diabetes	Idiopathic	Postoperative					
Moszkowicz et al. 2022	Bypass	Retrospective	July 2016–September 2020	9	37.2 (16.6)	7:2	5	2	2	NA	12	NA	1 (11%) operation for internal hernia	1 (11%)
Cuenca Abente et al. 2020	Bypass	Retrospective	Not specified	1	32 (NA)	0:1	NA	NA	NA	NA	At least 12	NA	NA	None
Park et al. 2019	Bypass	Case report	Not specified	1	37 (NA)	0:1	1	0	0	NA	3	6	None	None
Wakamatsu et al. 2017	Bypass	Retrospective	February 2003–December 2014	15	51 (41–60)	13:2	NA	NA	NA	180 (155–211)	15.5 (6–30)	4 (3–5)	1 (6%; small bowel obstruction)	1 (6%)
Sun et al. 2015	Bypass	Retrospective	March 2002–December 2012	7	40 \pm 2.5	6:1	1	6	0	210 \pm 115	20	5.1 \pm 4.5	1 (14.2%; duodenal stump leak)	none
Papasavas et al. 2014	Bypass	Retrospective	December 2010–February 2013	7	48 (27–59)	6:1	2	5	0	NA	10.4 (5–24.2)	NA	None	2 (28.6%)
Gerritsen et al. 2013	bypass	Retrospective	January 1995–December 2010	11	51.7 \pm 10.4	7:4	0	0	11	144 \pm 37	102 \pm 59	12 \pm 5	1 (9%; wound infection)	none
Zehetner et al. 2013	Bypass	Retrospective	January 2003–January 2012	31	53.3 (41–62)	22:9	12	8	11	213 (162–259)	26.8	9 (9–13)	7 (22.6%; n = 2 wound infections; n = 2 sepsis; n = 1 atrial fibrillation; n = 1 myocardial infarction; n = 1 small bowel obstruction)	CD
Watkins et al. 2003	Bypass	Retrospective	1994–2000	7	32 (28–37)	7:0	7	0	0	NA	Between 6 and 72	NA	None	1 (14.2%)
Zarate et al. 2003	Bypass	Case report	Not specified	1	32 (NA)	1:0	NA	NA	NA	NA	NA	NA	None	None
Ejskjaer et al. 1999	Bypass	Case report	1996–1998	4	31 (28–36)	4:0	4	0	0	NA	Between 9 and 30	NA	None	2 (50%)
Alicuben et al. 2020	Sleeve	Retrospective	September 2016–December 2017	10	43 (23–63)	8:2	4	5	1	NA	13	5 (2–13)	3 (10%; acute kidney injury; superficial wound infection; pulmonary embolism)	None
Lee et al. 2020	Sleeve	Retrospective	13-yr period (not specified)	19	54 (23–68)	9:10	1	9	9	NA	24	NA	2 (10.5%; n = 1 fistula from stomach to an incision; n = 1 ileus)	None

(continued on next page)

Table 1 (continued)

Study	Type of intervention	Study design	Study period	Number of patients	Age (yr), median (IQR) or mean \pm SD	Sex (female:male)	Etiology of gastroparesis			Procedure time (min), median (IQR) or mean \pm SD	Follow-up (mo), median (IQR) or mean \pm SD	Hospital stay (d), median (IQR) or mean \pm SD	Postoperative complications, n (%)	Readmission, n (%)
							Diabetes	Idiopathic	Postoperative					
Ude et al. 2018	Sleeve	Case report	Not specified	4	42 (27.3–55.5)	4:0	4	0	0	NA	Between 2 and 12	NA	1 (25%; pain at port site)	2 (50%)
Samuel et al. 2016	Sleeve	Case report	Not specified	2	45 (42.5–47.5)	2:0	0	2	0	NA	Between 5 and 24	NA	None	None
Le Page et al. 2015	Sleeve	Case report	Not specified	4	63.5 (61–64)	NA	NA	NA	NA	NA	Between 4 and 25	NA	None	None
Landreneau et al. 2020	RY, stomach left in situ	Retrospective	September 2010–March 2018	26	49.7 \pm 11.9		7	11	8	155 \pm 42	12.3 (3.3–15.5)	4 \pm 1.4	2 (7.7%; wound infection; cardiac arrest after discharge)	1 (3.8%)
	Subtotal gastrectomy with RY bypass			27	48.5 \pm 14.0		6	5	16	223 \pm 67	11.3 (3.1–22.1)	7.6 \pm 5.6	12 (44.4%; n = 6 infections; n = 5 reoperations; n = 2 gastrointestinal hemorrhages; n = 1 deep vein thrombosis)	10 (37%)
Bhayani et al. 2015	Near-total gastrectomy with RY bypass	Retrospective	1999–2013	35	30 (NA)	30:5	12	8	15	NA	6	4.5 (2–16)	10 (28.6%; n = 6 leakages of anastomosis warranting reoperation; n = 3 wound infections; n = 1 hematoma)	None
Katz et al. 1999	Subtotal gastrectomy (Billroth I)	Case report	Not specified	1	15 (NA)	0:1	0	0	1	NA	36	NA	None	None

IQR = interquartile range; SD = standard deviation; NA = not applicable; CD = cannot be determined; RY = Roux-en-Y.

postoperatively could be calculated for 10 studies, with a decrease in BMI for 8 studies, ranging between 4.2% and 24% change in BMI compared with preoperatively. In 1 study, BMI increased by 19%; another study reported an increase in weight of 10 kg but did not report total weight preoperatively or postoperatively (Table 3). In one study, BMI changes were mentioned separately for patients with obesity with refractory gastroparesis (decrease in BMI by 24%) and malnourished patients with refractory gastroparesis (increase in BMI by 4.5%) [35].

Symptom improvement and symptom scoring

Improvement in most predominant symptoms was seen in all studies, either with total resolution of symptoms or with partial response. Symptoms that were reported most often preoperatively included nausea, vomiting, early satiety, and epigastric pain. The predominant symptoms included nausea and vomiting. Nausea was reported as the main symptom in 10 of 19 included studies [16,17,24,26–29,35–37], and the presence ranged between 31% of patients included in the study [24] and up to 100% of study patients [29]. Vomiting as the main symptom was reported in between 36% of patients [27] and up to 100% of patients [25] and was reported as the predominant symptom in 14 of 19 studies [16–21,25–29,35–37]. Both symptoms showed major or complete improvement in patients after surgery: for nausea, complete improvement of symptoms ranging between 55% (6 of 11 patients [28]) and up to 100% of patients (1 of 1 patient [37]), and significant improvement in between 70% and 80% of patients was seen [20,24,26,27,29,36]. Postoperatively, between 65% of patients (6 of 26 patients [28]) and up to 100% of patients (9 of 9 patients [25,27,37]), with complete disappearance of vomiting noticed. In patients with vomiting still present after surgery, significant improvement in severity and frequency was noticed [16,18,19,21,26,28], for example, from several times daily to less than once a month [35]. No pooling of results was performed because only 5 studies used a validated questionnaire to assess symptoms pre- and postoperatively with different scoring systems (Table 4). Four studies used the GCSI [20,23,28,35], while 1 study used the Gastroesophageal Reflux Disease–Health Related Quality of Life system [15], and another study used the Gastrointestinal Quality of Life Index (GIQLI) [16]. Four studies [15,16,23] measured both pre- and postoperatively, and all showed improvement in symptom scores (varying between 42% and 83% improvement). For the 3 studies [15,16,23] with sleeve gastrectomy as the intervention, improvement on the GCSI was seen in 45%–83%; for Roux-en-Y gastric bypass, only 1 study reported 42% improvement on the GCSI. Weighted-average improvements in symptom scores were reported as 42.2%–52.9% when considering sleeve gastrectomy only.

Effect of intervention on gastric emptying

Five studies reported values of gastric emptying both pre- and postoperatively, by calculating $T_{1/2}$ times based on retention measurement at either 120 minutes or 4 hours. Four studies [13,15,16,18,36] with sleeve gastrectomy as the intervention reported gastric emptying times pre- and postoperatively with an improvement (e.g., decrease in $T_{1/2}$ emptying time) ranging between 45% and 67%, whereas in 1 study an increase of 50 minutes of $T_{1/2}$ emptying time was reported [36]. One study on Roux-en-Y gastric bypass surgery [18] reported an 87% improvement postoperatively of gastric emptying while using an estimated $T_{1/2}$ (Supplementary Table 1). Average improvement across studies when weighted according to included patients in separate studies was 43.1% (sleeve gastrectomy and Roux-en-Y gastric bypass) and 41.6% when considering only sleeve gastrectomy.

Adverse events

Most common reported postoperative adverse events included infection (n = 14 events; 29% of a total of 49 reported adverse events) and reoperation (n = 15; 31% of a total of 49 reported adverse events; Fig. 2). Indications for reoperation included leakage of the anastomosis (n = 7 patients), small bowel obstruction (n = 2 patients), and internal herniation (n = 1 patient); the reason for reoperation was not specified for 5 patients [28]. There were 8 studies [13,15,17–19,25,34,37] that reported no postoperative complications (of a total of 21 studied patients from these studies), whereas in the remaining 11 studies (including a total of 201 patients), a total of 49 adverse events were reported.

Discussion

The findings of our systematic review suggest that sleeve gastrectomy, subtotal gastrectomy, and Roux-en-Y gastric bypass surgery may improve symptoms and quality of life in patients with refractory gastroparesis. Although pooling of results with regard to symptoms or emptying rates was not possible due to heterogeneity among the included studies, all studies reported on the clinical success of surgery in patients with refractory gastroparesis. Improvement in gastric emptying rates was seen ranging from 45% to up to 65% for sleeve gastrectomy and 87% for Roux-en-Y gastric bypass. Symptoms improved postoperatively from 42% to up to 83% maximum according to the GCSI.

As is stated in clinical guidelines on gastroparesis, a step-wise approach should be considered with as a first step adjustment of diet and nutritional support, which may be sufficient for almost 60% of patients with mild gastroparesis [4,10]. Once symptoms may not be sufficiently controlled by diet adjustment, medication (such as prokinetics and antiemetics) may be warranted in order to maintain nutritional

Table 2
Quality assessment of studies with National Institutes of Health quality assessment tool for case series

Question	Moszkowicz	Cuenca	Park	Wakamatsu	Sun	Papasavas	Gerritsen	Zehetner	Watkins	Zarate	Ejksjaer	Alicuben	Lee	Samuel	Le	Landreneau	Bhayani	Katz
Was the study question or objective clearly stated?	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	N	N
Was the study population clearly and fully described, including a case definition?	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y
Were the cases consecutive?	CD	CD	NA	Y	CD	Y	CD	Y	Y	NA	CD	CD	Y	CD	CD	CD	CD	NA
Were the subjects comparable?	Y	NA	NA	Y	Y	Y	Y	Y	Y	NA	Y	Y	Y	Y	Y	Y	Y	NA
Was the intervention clearly described?	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	N	Y	Y	Y	Y
Were the outcome measures clearly defined, valid, reliable, and implemented consistently across all study participants?	Y	N	NA	N	Y	Y	Y	N	N	NA	N	Y	Y	NA	N	N	CD	Y
Was the length of follow-up adequate?	Y	Y	N	Y	Y	Y	Y	Y	Y	CD	Y	Y	Y	Y	Y	Y	N	Y
Were the statistical methods well described?	Y	NA	NA	Y	NA	NA	Y	NA	NA	NA	NA	Y	Y	NA	NA	Y	Y	NA
Were the results well described?	Y	N	Y	Y	Y	Y	Y	N	N	Y	Y	Y	Y	Y	Y	Y	Y	Y

Y = yes; N = no; NA = not applicable; CD = cannot be determined.

status and weight. However, around 40% of patients fail on these initial steps and need a period of gastric rest lasting at least 3 months or even may depend on long-term enteral tube feeding [4]. Several therapies have been introduced in recent years for the 14% of patients without improvement of symptoms over time while nutritional support is maintained. GES by a gastric pacemaker has several electrophysiologic effects and has been shown to reduce symptoms such as nausea and vomiting in open-label studies and in a recent randomized trial [38]. However randomized controlled trials did not demonstrate a significant benefit of GES over placebo in terms of gastric emptying and quality of life [8,38,39]. Subsequently, open or laparoscopic pyloroplasty/pyloromyotomy has shown improvement in symptoms [9]. The minimally invasive G-POEM has gained increasing interest since its introduction in 2013 [40] and has shown promising improvement in clinical response and gastric emptying studies [5,6,41]. However, data on improvement of symptoms in the longer term after G-POEM are scarce [41,42]. In a systematic review from Zoll et al. [43], a comparison was made across various interventions for gastroparesis, including gastric pacemaker, pyloric interventions, and (partial or subtotal) gastrectomy. In line with our results, patients who underwent gastrectomy showed a 37% improvement in symptoms of epigastric pain and 65% in vomiting, a result that was similar to that of pyloric intervention but better than gastric pacemaker [43]. Whether the efficacy of surgery still holds for patients who failed on prior G-POEM or surgical pyloroplasty is unclear. One may hypothesize that if antral hypomotility is a component in the pathophysiology of gastroparesis, interventions still relying on some antral pump activity (e.g., G-POEM, pyloroplasty, and sleeve gastrectomy) may be less efficacious than when this is not needed, for instance, with Roux-en-Y gastric bypass surgery.

Preferentially all patients with gastroparesis are evaluated systematically for efficacy of treatment strategies in terms of symptom improvement and objective measures such as emptying rates. In particular, when surgery is considered, a structured patient-based symptom score, gastric emptying testing, need for prokinetic medication, tube feeding, and weight change pre- and postoperatively should be determined. Because of the complexity of co-morbid conditions in functional gastrointestinal disorders and their relation to perceived symptoms, we suggest that psychological screening before surgery should be considered routinely as well. Only a few studies included in this review reported on a patient-based symptom score such as the GCSI, which was developed and validated for symptom severity of gastroparesis [44]. Although 6 included studies used scoring systems to report on symptoms, 2 of the scoring systems were not specifically designed for gastroparesis but either for gastroesophageal reflux disease (GERD) health-related quality of life [15] or gastrointestinal symptoms-related quality of life [16]. However, the GIQLI has been used

Table 3
Effect of intervention on body mass index

Study	Type of intervention	Patients, n	Body mass index (kg/m ²) preoperatively, median (IQR) or mean ± SD	Body mass index (kg/m ²) postoperatively, median (IQR) or mean ± SD	Change in body mass index (kg/m ²)	
					Absolute	%
Moskowitz et al. 2022	Bypass	9	19.9 (16.4–23.4) in malnourished patients 45.6 (31.5–37.5) in patients with obesity	20.8 (17.3–24.6); 31.9 (28–35.8)	Increase 0.9 in malnourished patients decrease 10.4 in patients with obesity	4.5% in malnourished patients; 30% in patients with obesity
Cuenca Abente et al. 2020	Bypass	1	31.7	29.2	2.5	7.9
Park et al. 2019	Bypass	1	20.1	18.6	1.5	7.5
Wakamatsu et al. 2017	Bypass	15	35.7 (26–38)	Unknown	NA	
Sun et al. 2015	Bypass	7	36.9 ± 2.2	29.2 ± 4.8	7.7 ± 4	20.9
Papasavas et al. 2014	Bypass	7	39.5 (33–54)	30.4	9.1 (7–19)	23.0
Gerritsen et al. 2013	Bypass	11	22 ± 2.4	Unknown	NA	
Zehetner et al. 2013	Bypass	31	Unknown	Unknown	NA	
Watkins et al. 2003	Bypass	7	Unknown	Unknown	NA	
Zarate et al. 2003	Bypass	1	Unknown	Unknown	NA	
Ejskjaer et al. 1999	Bypass	4	21*	Unknown	NA	
Alicuben et al. 2020	Sleeve	10	24.5 (16.8–39.6)	Unknown	NA	
Lee et al. 2020	Sleeve	19	24	23	1	4.2
Ude et al. 2018	Sleeve	4	25.9 (21.7–30.4)	31 (26.6–31.7) [†]	5.1	–19.7 [‡]
Samuel et al. 2016	Sleeve	2	49	39	10	20.4
Le Page et al. 2015	Sleeve	4	27	24	3	11.1
Landreneau et al. 2020	Bypass, stomach left in situ	26	34.3 ± 6.8	Unknown	NA	
Landreneau et al. 2020	Subtotal gastrectomy with RY bypass	27	29.2 ± 7.3	Unknown	NA	
Bhayani et al. 2015	Near-total gastrectomy with RY bypass	35	32.9 (20.2–49.9)	25.0 (19.1–47)	7.9	24.0
Katz et al. 1999	Subtotal gastrectomy (Billroth I)	1	Unknown	Unknown	Increase in 10 kg	

IQR = interquartile range; SD = standard deviation; NA = not applicable; RY = Roux-en-Y.

* Body mass index from 1 patient only.

[†] Body mass index from 3 patients.

[‡] Means an increase in body mass index postoperatively compared with preoperatively.

successfully in patients with gastroparesis [45]. In the study by Lee et al. [16], the GIQLI score does improve to levels seen in a healthy population, thereby showing improvement in symptoms and symptom-related quality of life. The GCSI, in contrast, was intended to evaluate nonsurgical therapies and has not been validated for postoperative interventions. Future studies are needed with validated scoring systems, such as the GCSI or PAGI-SYM, to compare the efficacy of therapies for gastroparesis while taking patient outcomes into account [44].

Only few studies [13,15,16,18] reported improvement of gastric emptying testing in postoperative patients. However, validation of gastric emptying testing after sleeve

gastrectomy or Roux-en-Y gastric bypass surgery has not been performed. From the previous literature on patients with obesity, we know that gastric emptying rates after sleeve gastrectomy [12,14,46] and small intestinal motility patterns after Roux-en-Y gastric bypass surgery may increase [11]. Apart from a change in anatomy after surgery, which solely may result in emptying changes, whether the different extent of vagal dissection in sleeve gastrectomy compared with Roux-en-Y gastric bypass surgery [47] may contribute to a significant improvement in gastric function remains to be elucidated.

Surgery is a drastic procedure that cannot be reversed and is associated with complications. Regarding sleeve

Table 4
Studies with symptom scoring systems

Author	Intervention	Symptom scoring system	Preoperative score	Postoperative score	Delta improvement	Note
Moszkowicz et al. 2022	Bypass	GCSI	3.6 (1–5)	2.1 (.3–4.4)	42%	
Zehetner et al. 2013	Bypass	GCSI	15	Not mentioned		Median total GCSI score GCSI score calculated from completed PGI-SYM questionnaire
Alicuben et al. 2020	Sleeve	GCSI/PAGI SYM	33.6	14.9	56%	
Lee et al. 2020	Sleeve	GIQLI	78 (44–89)	114 (87–120)	45%	
Le Page et al. 2015	Sleeve	GERD-HRQL	23 (3–25)	4 (0–8)	83%	
Landreaneau et al. 2020	Bypass, stomach left in situ	GCSI	Not mentioned	2.4 (\pm 1.4)		
Landreaneau et al. 2020	Subtotal gastrectomy with RY bypass	GCSI	Not mentioned	2.5 (\pm 1.3)		

GERD-HRQL = Gastroesophageal Reflux Disease–Health Related Quality of Life; GCSI = Gastroparesis Cardinal Symptom Index; PGI SYM = Patient Assessment of Upper Gastrointestinal Disorders–Symptoms Severity Index; GIQLI = Gastrointestinal Quality of Life Index; RY = Roux-en-Y.

gastrectomy, bleeding and leakage of the anastomosis occur in the short term, and up to 23% of patients develop de novo GERD symptoms [48,49], and up to 12% of patients develop Barrett's esophagus after sleeve gastrectomy [48,50]. In Roux-en-Y gastric bypass surgery, internal herniation or dumping syndrome may occur. In the studies included in this review, these complications have not been taken into account, and therefore, no conclusions can be drawn on these adverse events in gastroparesis patients. Furthermore, whether dumping occurs more often in patients with sleeve gastrectomy who underwent pyloroplasty or G-POEM before surgery compared with those who have not is uncertain. Only a small proportion of patients who received surgery had a prior pyloric intervention

(Supplementary Table 2). Unfortunately, no data are available to compare subgroups.

Patients with gastroparesis suffer from symptoms and struggle to maintain weight at a normal or stable BMI level. Once this cannot be achieved, gastroparesis is considered to be decompensated, and sequential treatment steps are needed [4]. Although no information was known about the amount of weight lost before, at the time of, or during conservative management of a diagnosis of gastroparesis, reported BMI values of studied patients is noticeably high: a median or mean BMI >25 kg/m² preoperatively for 9 included studies [13,15,17,24,26,28,29,34,36]. Only 1 study reported results separately for patients with obesity with refractory gastroparesis and malnourished gastroparesis

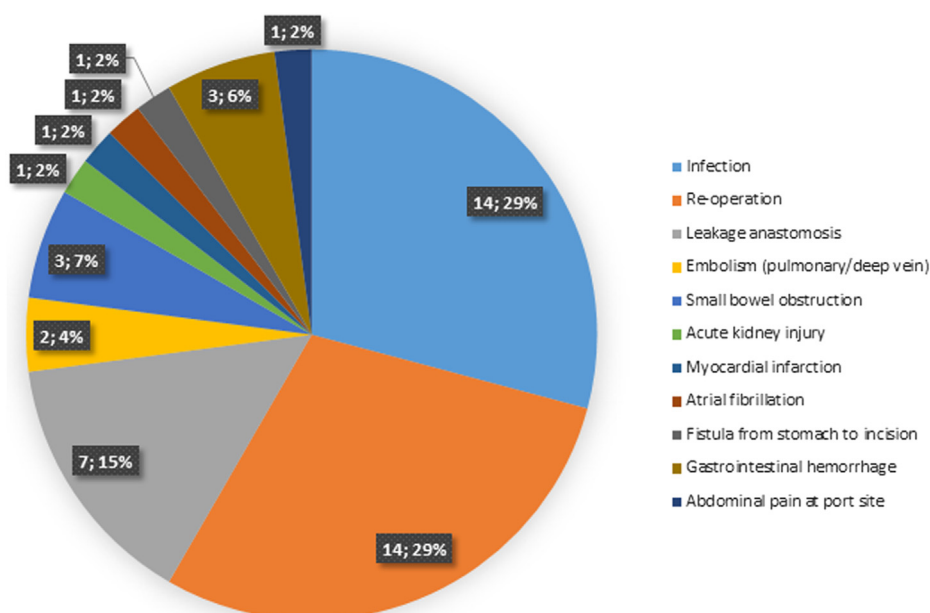


Fig. 2. Adverse events (n; % of adverse events).

patients (defined as a weight loss of $\geq 5\%$ in 1 month or of $\geq 10\%$ in 6 months or a BMI of $< 18.5 \text{ kg/m}^2$ with a 50% reduction in food intake) and reports favorable outcomes in terms of symptoms but also weight/BMI changes in both groups at 1 year postoperatively [35]. As reported previously, surgery (sleeve gastrectomy or Roux-en-Y gastric bypass surgery) was more often chosen over pyloroplasty or GES in gastroparesis patients with a BMI of $> 35 \text{ kg/m}^2$ and failure on medical therapy [51]. However, whether the etiology of gastroparesis or certain patient factors influence the surgical outcome is unclear. Selection and stratification of certain subgroups of patients for surgery—for example, those with or without prior pyloric intervention or those with certain etiologic causes of gastroparesis—should be elucidated in the future. One may suggest that Roux-en-Y gastric bypass may be preferred over sleeve gastrectomy in patients with obesity and gastroparesis or in those with gastroparesis and GERD or Barrett's esophagus. Otherwise, if sleeve gastrectomy is not sufficient for symptom control, Roux-en-Y gastric bypass may be performed as a second step.

Furthermore, endoscopic sleeve gastroplasty—with the same intention as laparoscopic sleeve gastrectomy by creating a funnel-shaped remnant stomach without disruption of the gastric vascular and vagal nerve—has been shown to result in weight loss in patients with obesity [52]. Whether an endoscopic gastroplasty also may enhance gastric emptying due to the tubular stomach shape in gastroparesis is unclear but may be interesting for future research because of its less invasive nature.

This is the first systematic review on gastric sleeve, subtotal gastrectomy, and gastrectomy with Roux-en-Y gastric bypass surgery reporting on efficacy in terms of symptoms and gastric emptying for refractory gastroparesis. However, scarcity of data and heterogeneity among the retrospective studies and case reports limited our ability to report results with regard to specific symptoms or the etiology of gastroparesis by type of intervention. This stresses the need for more thorough and systematic evaluations in the future. Another limitation of this review is that we included all types of articles irrespective of date of publication. Surgical indications, choices, and techniques have evolved over time, which may have resulted in better surgical outcomes reported in more recent studies.

In conclusion, the findings of our systematic review suggest that sleeve gastrectomy, subtotal gastrectomy, and Roux-en-Y gastric bypass surgery may be effective for symptom improvement and gastric emptying in patients with otherwise refractory gastroparesis. Surgery may be effective as treatment for a small group of patients when all other therapies have failed. Future studies are needed

to identify whether specific subgroups of refractory gastroparesis patients may benefit the most from gastric surgery.

Disclosures

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Supplementary materials

Supplementary material associated with this article can be found, in the online version, at <https://doi.org/10.1016/j.soard.2022.09.009>

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