Obesity Surgery
https://doi.org/10.1007/s11695-022-06254-y

ORIGINAL CONTRIBUTIONS

Comparative Effectiveness and Safety Between Endoscopic Sleeve Gastroplasty and Laparoscopic Sleeve Gastrectomy: a Meta-analysis of 6775 Individuals with Obesity

Azizullah Beran[1] · Reem Matar[2,3] · Veeravich Jaruvongvanich[3] · Babusai B. Rapaka[3] · Abdullah Alalwan[4] · Ray Portela[5] · Omar Ghanem[5] · Barham K. Abu Dayyeh[3]

Received: 3 May 2022 / Revised: 9 August 2022 / Accepted: 19 August 2022

Abstract

Introduction Endoscopic sleeve gastroplasty (ESG) is a novel endoscopic bariatric therapy that complements current medical and surgical therapeutic offerings for weight management and fills an unmet need. Few meta-analyses compared ESG to laparoscopic sleeve gastrectomy (LSG). However, these studies relied on indirect evidence derived from non-comparative studies. Comparative effectiveness data derived from direct comparative studies is needed. We performed a meta-analysis of studies that directly compared ESG with LSG.

Methods A comprehensive search of PubMed, Embase, and Cochrane databases was conducted. Single-arm studies were excluded. Pooled mean difference (MD) and risk ratio (RR) with 95% confidence intervals (CIs) were obtained within a random-effect model.

Results Seven studies with 6,775 patients (3,413 with ESG vs. 3,362 with LSG) were included. There were significant differences in 6-month (MD −7.48; 95% CI −10.44, −4.52; $P<0.00001$), 12-month (MD −9.90; 95% CI −10.59, −9.22; $P<0.00001$), and 24-month (MD −7.63; 95% CI −11.31, −3.94; $P<0.0001$) TBWL% favoring LSG over ESG. There was a trend toward lower incidence of adverse events with ESG compared to LSG but did not reach statistical significance (RR 0.51, 95% CI 0.23–1.11, $P=0.09$). The incidence of new-onset gastroesophageal reflux disease (GERD) was significantly lower after ESG compared to LSG, 1.3% vs. 17.9%, respectively (RR 0.10, 95% CI 0.02–0.53, $P=0.006$).

Conclusions ESG achieved clinically adequate but lower short- and mid-term weight loss when compared to LSG, with fewer adverse events, including GERD. Given the stomach-sparing nature of ESG and acceptable safety profile, it provides an acceptable alternative to LSG for patients with mild-to-moderate obesity.

Keywords Endoscopic sleeve gastroplasty · Laparoscopic sleeve gastrectomy · Obesity · Weight loss

Key Points

- Compared to LSG, ESG achieved clinically adequate but lower short-term weight loss.
- The adverse events profile trended in favor of ESG with lower incidence of new-onset GERD in the ESG cohort.
- ESG is an acceptable minimally invasive option for poor surgical candidates or those pursuing alternative options to bariatric surgeries.

✉ Barham K. Abu Dayyeh
AbuDayyeh.Barham@mayo.edu

1 Divison of Gastroenterology and Hepatology, Indiana University, Indianapolis, IN 46202, USA

2 St George's University of London, London SW17 0RE, UK

3 Division of Gastroenterology and Hepatology, Mayo Clinic, 200 First Street SW, Rochester, MN 55905, USA

4 Department of Surgery, University of Toledo, Toledo, OH 43606, USA

5 Department of Surgery, Mayo Clinic, Rochester, MN 55905, USA

Introduction

There is a worldwide epidemic of obesity that has significant health and economic burden [1, 2]. Obesity rates nearly tripled from 1975 to 2016 globally [3]. Obesity is associated with increased morbidity and mortality, given the contribution of excess adiposity to chronic diseases, such as cardiovascular disease, diabetes, hypertension, hyperlipidemia, liver and kidney disease, cancer, and obstructive sleep apnea [4]. Management of obesity needs a multipronged and multidisciplinary approach congruent with the heterogeneous nature of the disease [5]. Bariatric surgery is the most effective treatment for morbid obesity in terms of long-term weight loss, comorbidities improvement, and overall mortality improvement [6]. Laparoscopic sleeve gastrectomy (LSG) is the most prevalent bariatric surgery, accounting for 58.1% of the bariatric surgeries performed annually in the USA [7]. LSG is a partial vertical gastrectomy procedure that removes the stomach's fundus and greater curvature, resulting in gastric tubularization. Although LSG is an effective bariatric surgery, it is associated with acute and chronic surgical complications such as bleeding, leaks, and fistulae [8]. More recently, there have been increased concerns that LSG exacerbates gastroesophageal reflux disease and may contribute to an increased risk of Barrett's esophagus [9, 10]. Thus, an anatomy-sparing intervention, such as endoscopic sleeve gastroplasty (ESG), might provide an alternative approach in patients with mild-to-moderate obesity or those who refuse LSG.

ESG is a novel endobariatric procedure that has gained momentum recently as a stomach-sparing per-oral procedure with favorable alteration to satiety and satiation pathways resulting in weight loss and metabolic benefit [11, 12]. In ESG, a funnel-shaped gastric configuration is achieved by imbricating the greater curvature of the stomach from the level of the incisura to the gastric cardia leaving a small pouch in the fundus. The procedure is performed using a per-oral endoscopic full-thickness suturing device (Overstitch, Apollo Endosurgery, Auston, Texas). Many studies have indicated that ESG can be beneficial in terms of being a less invasive, reversible, less expensive, and safer approach while still achieving acceptable short- to medium-term weight loss results [11, 13–15].

Few meta-analyses compared the efficacy and safety of ESG vs. LSG [16–18]. However, these studies have heterogeneous designs because they conducted an indirect comparison between ESG and LSG and pooled data from non-comparative studies. More comparative studies evaluating ESG and LSG have been published recently [19–21]. For these reasons, we performed a systematic review and meta-analysis, including studies that directly compared ESG with LSG in terms of safety and efficacy.

Methods

We conducted this systematic review and meta-analysis based on the guidelines of the Preferred Reporting Items for Systematic Reviews and Meta-analysis [22] and Meta-analysis of Observational Studies in Epidemiology [23].

Data Sources and Search Strategy

We performed a systematic search for published studies indexed in PubMed, Embase, and Web of Science from inception to March 15, 2022. We also performed a manual search for additional relevant studies using references from the included articles. The following search terms were used: ("ESG" or "endoscopic sleeve gastroplasty") and ("LSG" or "laparoscopic sleeve gastrectomy"). The search was not limited by language, study design, or country of origin. Supplementary Table 1 describes the full search term used in each database searched.

Eligibility Criteria

All studies that performed a direct comparison between ESG and LSG in patients with obesity were eligible for inclusion. We excluded single-arm studies and conference abstracts. Outcomes of interest included total body weight loss percentage (TBWL%), excess weight loss percentage (EWL%), and adverse events. Two investigators (AB and RM) independently screened and selected the studies for the final review. Discrepancies were resolved by consensus. All data was downloaded and merged into the EndNote X9 reference manager database, and any duplicate citations were removed.

Data Extraction

The following data were extracted from the studies: first author name, publication year, country of origin, study design, sample size, gender and age of patients, preoperative body mass index (BMI), and follow-up duration. Outcome measures were retrieved, including TBWL%, EWL%, and adverse events. Two investigators (AB and RM) independently extracted data from the included studies using Microsoft Excel software. Discrepancies were resolved by consensus.

Outcomes of Interest

The primary outcomes of our study were weight loss outcomes in the form of TBWL% and EWL% and overall adverse event rate. The secondary outcome was remission/improvement of comorbidities and new-onset gastroesophageal reflux disease (GERD).

Statistical Analysis

We performed a meta-analysis of the included studies using Review Manager 5.3 (Cochrane Collaboration, Copenhagen, The Nordic Cochrane Centre) and Open Meta Analyst (CEBM, Oxford, UK). The median and interquartile ranges were converted to mean and SD where applicable [24]. The random-effects model with Mantel–Haenszel method was used to calculate the pooled risk ratio (RR) and mean difference (MD) with the corresponding confidence intervals (CIs) for proportional and continuous variables, respectively [25]. A P-value < 0.05 was considered statistically significant. The heterogeneity was evaluated using the I^2 statistic as defined by the Cochrane handbook for systematic reviews. I^2 value of ≥ 50% was considered significant heterogeneity for all outcomes [26]. To confirm our results' robustness, we performed sensitivity analysis for outcomes reported by ≥ 5 studies using a leave-one-out meta-analysis to see if it significantly influenced the meta-analysis result (i.e., jack-knife sensitivity analysis).

Bias Assessment

The Newcastle Ottawa Quality Assessment Scale (NOS) was used to assess the quality of the observational studies based on the selection of the study groups, comparability of study groups, and ascertainment of exposure/outcome [27]. Studies with total scores of ≥ 6 were considered to have a low risk of bias. Two authors (AB and RM) independently assessed each study for bias. Discrepancies were resolved by consensus. Due to the small number of included studies (< 10 studies), we were unable to analyze publication bias.

Results

Study Selection

Our search strategy retrieved a total of 683 studies. Among these, 12 studies were eligible for systematic review. Subsequently, we excluded five studies because of a lack of appropriate comparison, ongoing trial, or conference abstracts (not peer-reviewed). Eventually, seven studies [14, 19–21, 28–30] met our inclusion criteria and were included in the meta-analysis. Figure 1 shows the PRISMA flow chart that illustrates how the final studies were selected.

Study and Patients' Characteristics

Table 1 shows details of studies included in the meta-analysis. All studies were published between 2018 and 2022. Based on country of origin, three studies [21, 28, 29] originated from Europe (France and Spain), two studies [14, 30] from the USA, one study [19] from Australia, and one study [20] from Saudi Arabia. All studies were observational studies: five studies [14, 20, 21, 28, 30] were retrospective cohort studies while two studies [19, 29] were prospective cohort studies. A total of 6,775 patients were included (3,413 patients in the ESG group vs. 3,362 in the LSG group). The mean age was 34.9 ± 10.2 years, and females represented 87% of the total patients. Mean baseline BMI was 33.7 ± 4.8 kg/m^2. Follow-up periods ranged from 6 to 36 months.

Efficacy of ESG vs. LSG

Table 2 summarizes the outcomes of the individual studies included in the meta-analysis. All seven studies, which included 5,516 patients, reported TBWL% at 6 months while four studies, which included 5,113 patients, reported TBWL% at 12 months and only two studies, which included 5,260 patients, reported TBWL% at 24 months. The pooled TBWL% for ESG at 6, 12, and 24 months were 15.2 ± 6.3, 19.1 ± 7.9, and 16.4 ± 10.1, respectively. The pooled TBWL% for LSG at 6, 12, and 24 months were 18.8 ± 7.5 and 28.9 ± 8.2, and 22.3 ± 8.3, respectively. There were significant differences in 6 months (MD − 7.48; 95% CI − 10.44, − 4.52; P < 0.00001; I^2 = 94%; Fig. 2A), 12 months (MD − 9.90; 95% CI − 10.59, − 9.22; P < 0.00001; I^2 = 9%; Fig. 2B), and 24 months (MD − 7.63; 95% CI − 11.31, − 3.94; P < 0.0001, I^2 = 85%, Fig. 2C) TBWL% favoring LSG over ESG. Consistent results were observed on leave-one-out sensitivity analysis for TBWL% at 6 months (Supplementary Fig. 1).

Three studies, which included 4,884 patients, reported EWL% at 6 months while only two studies, which included 4,642 patients, reported EWL% at 12 months. The pooled EWL% for ESG at 6 and 12 months were 66.7% ± 28.7 and 71.04% ± 24.6, respectively. The pooled EWL for LSG at 6 and 12 months were 76.6% ± 31.3 and 94.9% ± 20.6, respectively. There were significant differences in 6-month EWL% (MD − 10.23; 95% CI − 11.90, − 8.56; P < 0.00001; I^2 = 0%; Fig. 3A) and 12-month EWL% (MD − 23.99; 95% CI − 25.30, − 22.68; P < 0.00001; I^2 = 0%; Fig. 3B) favoring LSG over ESG.

Two studies reported the effect of ESG vs. LSG on comorbidities. The improvement or remission of diabetes mellitus was significantly higher with LSG compared to ESG, 81.9% vs. 64%, respectively (RR 0.78, 95% CI 0.68–0.91, P = 0.001, I^2 = 0%, Fig. 3C). The improvement or remission of hypertension was similar between the ESG and LSG groups, 51% vs. 45.6%, respectively (RR 1.12, 95% CI 0.86–1.47, P = 0.39, I^2 = 0%, Fig. 3D).

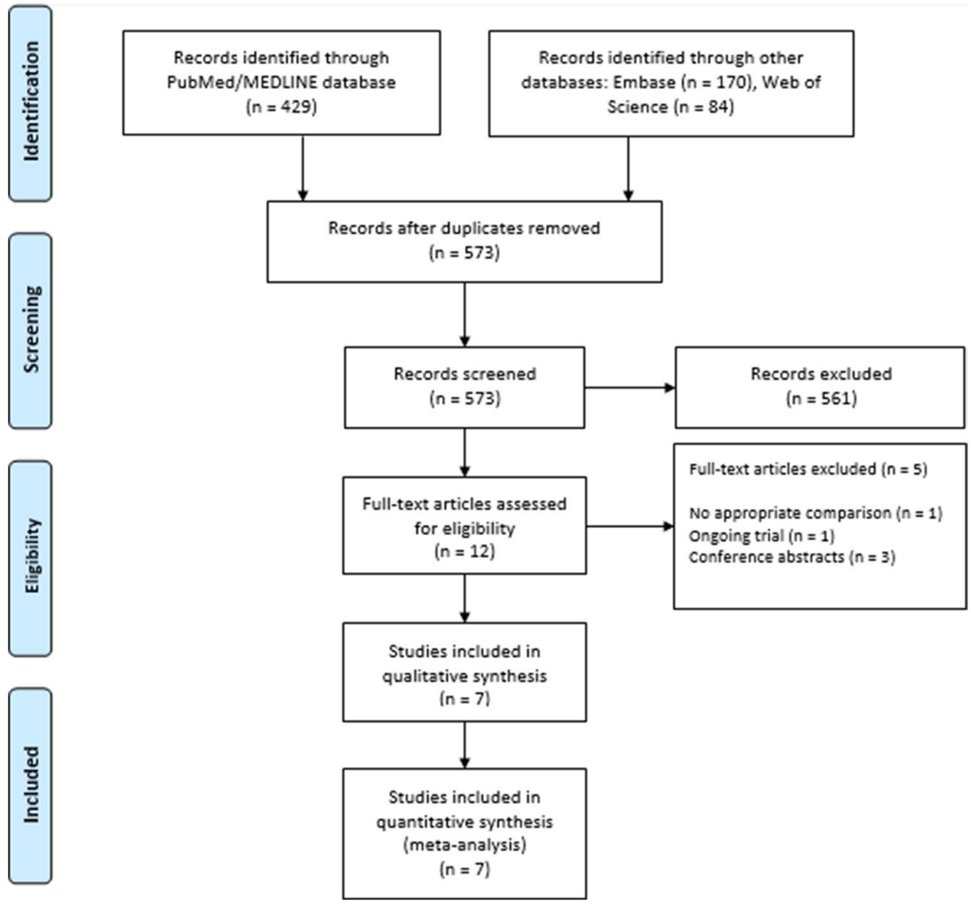

Fig. 1 PRISMA flow diagram for the selection of studies

Safety of ESG vs. LSG

All seven studies, which included 6,354 patients, reported overall adverse events. There was a trend toward a lower incidence of overall adverse events with ESG compared to LSG but did not reach statistical significance (RR 0.51, 95% CI 0.23–1.11, $P=0.09$, $I^2=50\%$, Fig. 4A). However, leave-one-out sensitivity by excluding Alqahtani et al. [20] moved the overall effect to favor ESG over LSG in terms of overall adverse events with an RR of 0.39 (95% CI 0.18–0.83, $P=0.01$) and resulted in $I^2=23\%$, suggesting that Alqahtani et al. was partly the reason for the significant between-study heterogeneity (Fig. 4B). The incidence of new-onset GERD was significantly lower after ESG compared to LSG, 1.3% vs. 17.9%, respectively (RR 0.10, 95% CI 0.02–0.53, $P=0.006$, $I^2=0\%$, Fig. 4C).

Quality Assessment

The overall quality assessment scores of the included studies are summarized in Table 1. Supplementary Table 2 shows the detailed quality assessment scores of the included studies. There was a low risk of bias for all the included studies, as shown in Supplementary Table 2.

Discussion

In this meta-analysis of seven comparative studies that included 6,775 patients, our results showed the superiority of LSG over ESG in terms of weight loss outcomes and improvement in type II diabetes mellitus, but no hypertension. The adverse events profile trended in favor of ESG with a lower incidence of new-onset GERD in the ESG cohort.

Our study results show that ESG can induce clinically adequate short- and mid-term weight loss at 6, 12, and 24 months. Our results were consistent with previous studies. For instance, Mohan et al. [16] reported the pooled TBWL% for ESG at 6 and 12 months of 15.3% and 17.1%, respectively. Our data indicate that the ESG group exceeded the American Society of Gastrointestinal Endoscopy's requirements for designating a beneficial endoscopic procedure for weight loss, which are ≥ 25%EWL and a 5% risk of major complications at 12 months [31]. ESG has the potential to bridge the present gap between the medical therapy of obesity and bariatric surgery. ESG and LSG have different mechanism of actions. After LSG, gastric motility tends to be accelerated, ghrelin levels decreased, post-prandial levels of gut hormone increased, and bile acid signaling altered conducive to weight loss and metabolic

Table 1 Study and baseline patients' characteristics of the included studies in the meta-analysis

Study, year	Study design	Country of origin	Total patients, *n* (ESG/LSG)	Follow-up duration	Age, mean ± SD, or median (IQR) (ESG/LSG)	Female, % (ESG/LSG)	Preoperative BMI, mean ± SD, or median (IQR), kg/m^2 (ESG/LSG)	Quality assessment scores of studies (NOS)
Alqahtani, 2022	RC	Saudi Arabia	6036 (3018/3018)	36 months (adverse events: 30 days)	33.8 ± 9.6/33.9 ± 9.7	89/89	32.5 ± 3.1/32.9 ± 3.5	7
Carr, 2022	PC	Australia	61 (16/45)	12 months	41.4 ± 10.4/40.4 ± 9.0	81.2/84.4	35.5 ± 5.2/40.7 ± 5.6	7
Fayad, 2019	RC	USA	137 (54/83)	6 months	48 (24–72)/47 (30–67)	57.4/71.1	43.07 (30.2–65.6)/44.12 (29.73–64.46)	7
Fiorillo, 2020	RC	France	46 (23/23)	6 months	41 (35–43)/37 (25–43)	69.6/73.9	39.5 (36.7–44.7)/41 (38.3–43.4)	7
Lopez-Nava, 2020	PC	Spain	24 (12/12)	6 months	49.3 ± 2.4/50.5 ± 1.9	75/75	38.3 ± 1.8/39.2 ± 1.5	8
Lopez-Nava, 2021	RC	Spain	260 (199/61)	24 months	44.6 ± 10/44.6 ± 11.2	71/59	39.4 ± 5.4/40.1 ± 3.7	7
Novikov, 2018	RC	USA	211 (91/120)	12 months	43.86 ± 11.26/40.71 ± 11.95	68.13/78.33	38.61 ± 6.98/47.22 ± 7.84	6

Abbreviations: *BMI*, body mass index; *ESG*, endoscopic sleeve gastroplasty; *IQR*, interquartile range; *LSG*, laparoscopic sleeve gastrectomy; *PC*, prospective cohort; *RC*, retrospective cohort; *SD*, standard deviation

Table 2 Outcomes of the included studies in the meta-analysis

Study, year	TBWL% (6 M), (ESG/LSG)	TBWL% (12 M), (ESG/LSG)	TBWL% (24 M), (ESG/LSG)	EWL% (6 M), (ESG/LSG)	EWL% (12 M), (ESG/LSG)	Overall adverse events, *n* (ESG/LSG)	New-onset GERD, *n* (ESG/LSG)
Alqahtani, 2022	15.1 ± 6.1/18 ± 7.3	19.2 ± 7.7/28.9 ± 8.2	16.2 ± 9.7/22.2 ± 8.2	67 ± 28.6/77 ± 31.4	77.1 ± 24.6/95.1 ± 20.5	14/10	NR
Carr, 2022	15 ± 6/24 ± 6	18 ± 11/30 ± 8	NR	51 ± 11/66 ± 25	57 ± 32/79 ± 24	4/12	NR
Fayad, 2019	17.1 ± 6.5/23.6 ± 7.6	NR	NR	NR	NR	3/14	1/12
Fiorillo, 2020	13.4 (7.8–20.9)/18.8 (17.6–21.8)	NR	NR	(39.9 (17.5–58.9)/54.9 (46.2–65)	NR	0/2	0/7
Lopez-Nava, 2020	13.3 ± 7/24.4 ± 4.8	NR	NR	NR	NR	0/0	NR
Lopez-Nava, 2021	16.8 ± 8.6/26.5 ± 6.8	18.6 ± 9.72/28.4 ± 7.16	18.5 ± 14.03/28.3 ± 8.4	NR	NR	1/3	NR
Novikov, 2018	14.4 ± 6.7/23.5 ± 6.6	17.6 ± 8.17/29.3 ± 8.2	NR	NR	NR	2/11	NR

Abbreviations: *ESG*, endoscopic sleeve gastroplasty; *EWL%*, excess weight loss percentage; *GERD*, gastroesophageal reflux disease; *IQR*, interquartile range; *LSG*, laparoscopic sleeve gastrectomy; *M*, month; *NR*, not reported; *SD*, standard deviation; *TBWL%*, total body weight loss percentage

improvements. These physiologic alterations are a function of the complete resection, devascularization, and denervation of the fundus and greater curvature of the stomach [32]. On the contrary, ESG impacts satiety and satiation by affecting gastric accommodation and delaying gastric emptying without similar changes in ghrelin and gut hormones, owing to the anatomy-sparing nature of the procedure without devascularization or denervation of any portion of the stomach [12]. These fundamental physiological differences between these two procedures and the narrower caliber of the ESG could explain the lower incidence of adverse events and GERD after ESG, and the enhanced efficacy of LSG [14, 29]. Although the weight nadir for ESG is lower than LSG (TBWL% 28.9 vs. 19.1, respectively) at 12 months,

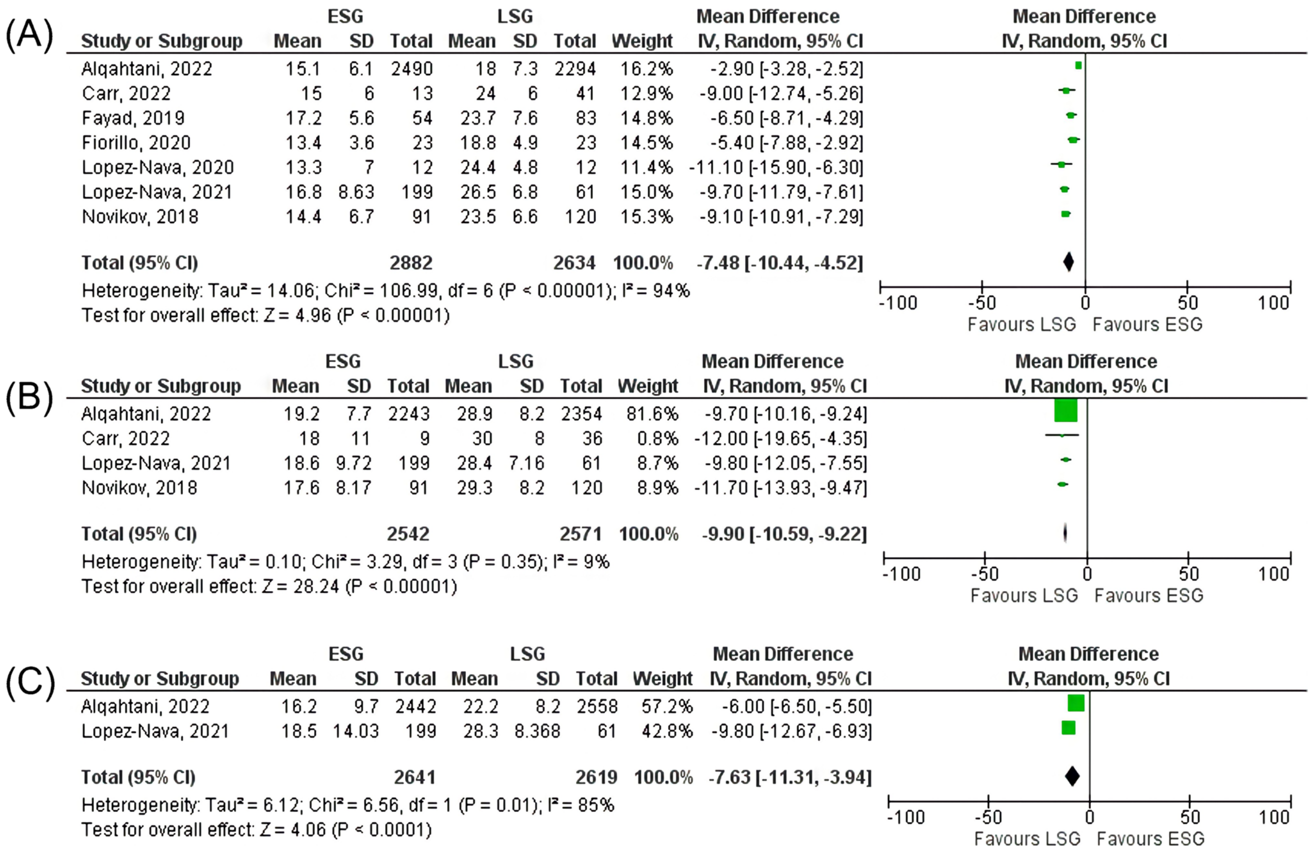

Fig. 2 Forest plots comparing between endoscopic sleeve gastroplasty and laparoscopic sleeve gastrectomy regarding total body weight loss percentage at: **A** 6 months, **B** 12 months, and **C** 24 months

both ESG and LSG had the most potential weight loss at 12 months. Longer-term comparative data is limited, with only one study by Alqahtani and colleagues [20] demonstrating non-inferiority of the 3-year ESG weight loss outcomes to LSG (TBWL% of 14 ± 12 and 18.8 ± 7.5, respectively). Thus, based on this meta-analysis, both procedures are complementary on the spectrum of interventions offered to patients with obesity.

The weight loss outcomes in our analysis were in line with previous meta-analyses, which showed that LSG was superior to ESG in terms of weight loss results [16, 17]. Our results were similar to those from the study by Mohan et al. [16], which reported that the pooled TBWL% at 6 months was 15.3% for ESG. Furthermore, the pooled TBWL% at 12 months was 17.1% and 30.5% for ESG and LSG, respectively. The pooled EWL% at 12 months were 62.2% and 80% for ESG and LSG, respectively, in the study by Jalal et al. [17]. However, our analysis was substantially affected by Alqahtani et al. [20], which was shown in the leave-one-out sensitivity analysis for TBWL% at 6 months and in the measurement of EWL% at 12 months. The EWL% for LSG at 12 months was 94.9% which is probably significantly higher than most published literature. Therefore, the significant difference observed in EWL% between ESG and LSG in our analysis may be significantly exaggerated by Alqahtani et al. [20].

Of note, laparoscopic greater curvature plication (LGCP) is another new, less invasive bariatric procedure that requires no resection [33]. Although LGCP resembles ESG in having a similar anatomic manipulation of the greater curvature of the stomach with no resection, they have a different approach [laparoscopic vs. endoscopic, respectively) and physiologic mechanism of action [34]. The target group appears to be comparable for endoscopic gastroplasty and plication, whereas patients who decide for sleeve gastrectomy are more motivated and choose to take a larger risk.

In our analysis, the incidence of overall adverse events tended to be lower in the ESG group (0.7%) compared to the LSG group (1.7%) but did not reach statistical significance. However, we believe that the estimate effect of overall adverse events was significantly deviated by Alqahtani et al. [20], given the change in the overall effect to favor ESG over LSG after excluding Alqahtani et al. (RR 0.39, 95% CI 0.18–0.83). After excluding Alqahtani et al., the overall adverse event rate was 2.5% and 12.2% for ESG and LSG, respectively. This is in line with the previous single-arm meta-analysis by Mohan et al., which showed

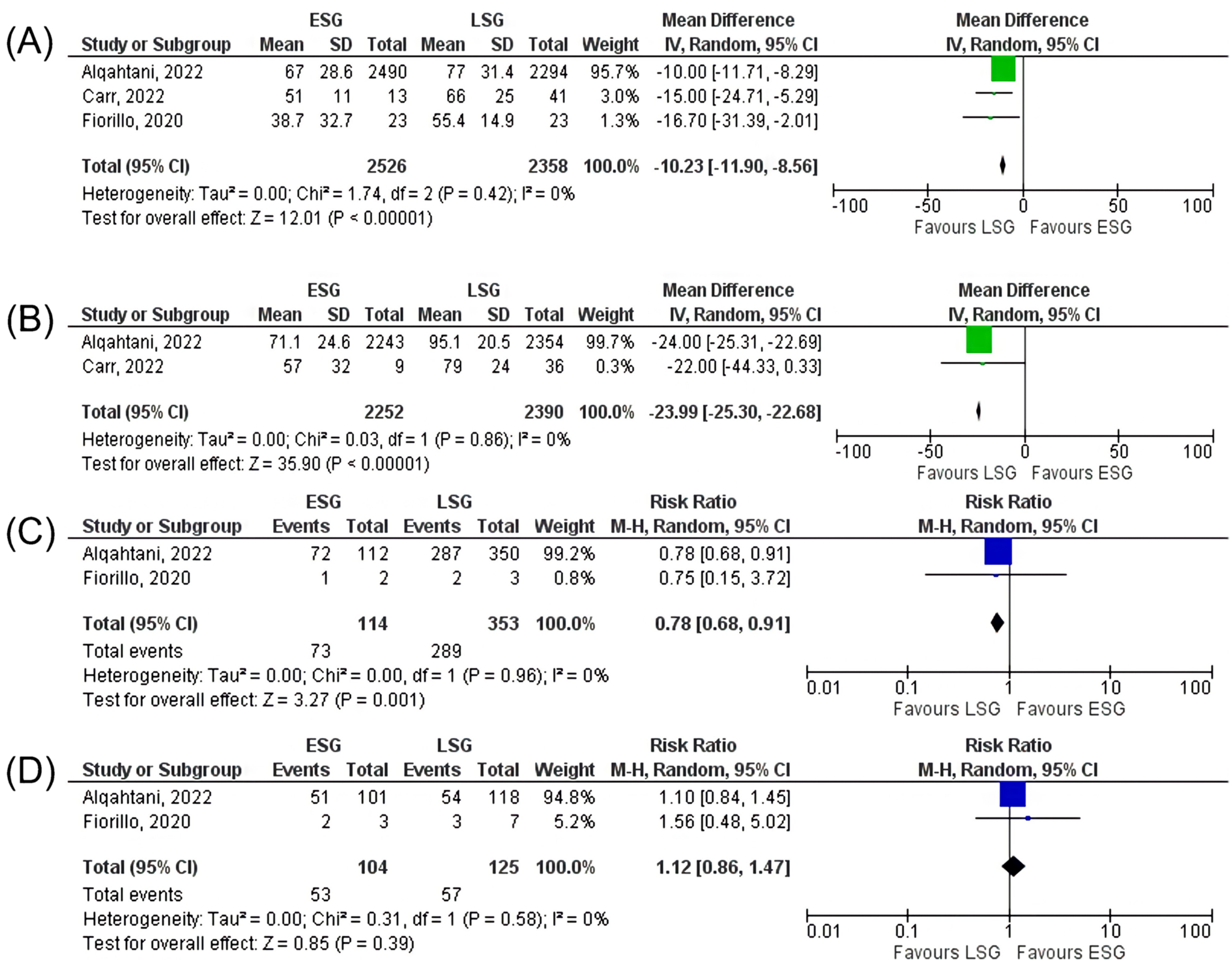

Fig. 3 Forest plots comparing between endoscopic sleeve gastroplasty and laparoscopic sleeve gastrectomy regarding excess weight loss percentage at: **A** 6 months and **B** 12 months. Forest plots comparing between endoscopic sleeve gastroplasty and laparoscopic sleeve gastrectomy regarding remission or improvement of: **C** diabetes mellitus and **D** hypertension

that ESG had 2.9% and LSG had 11.8% of overall adverse events. Alqahtani et al. had a short-term follow-up period for adverse events and evaluated the adverse events in the first 30 days post-procedure only, which can explain the shift in the overall effect on leave-one-out sensitivity analysis. Incidence of new-onset GERD was significantly lower with ESG than LSG in our study results (1.3% vs. 17.9%, $P=0.006$). The presence of significant GERD burden is generally considered a relative contraindication to LSG. In contrast to LSG, we found that ESG did not increase the risk of GERD.

We compared our meta-analysis to the previously performed analyses [16–18]. The main limitation of previous meta-analyses was the heterogeneous designs due to pooling data from single-arm studies and conducting an indirect comparison between ESG and LSG. To date, no meta-analysis in the literature compared ESG and LSG directly. Only a meta-analysis by Jalal et al. [17] performed a head-to-head comparison between ESG and LSG in terms of weight loss outcome. However, the analysis included only two studies and investigated only TBWL% at 6 months. To our knowledge, our study is the first meta-analysis to conduct a head-to-head comparison between ESG and LSG in patients with obesity. We excluded those studies that evaluated the outcomes of ESG or LSG separately to avoid biases and heterogeneity in the inclusion criteria that were present in previous meta-analyses [16–18].

Our study has certain limitations that should be acknowledged. First, this meta-analysis was based on observational studies only and lacked randomized controlled trials. Therefore, large-scale RCTs to compare ESG vs. LSG are warranted. Second, even though the random-effects model was used in our analysis, there was significant heterogeneity noted in the measurement of efficacy and safety outcomes. This might be driven by differences in patient characteristics, operator technique, the intensity and compliance of

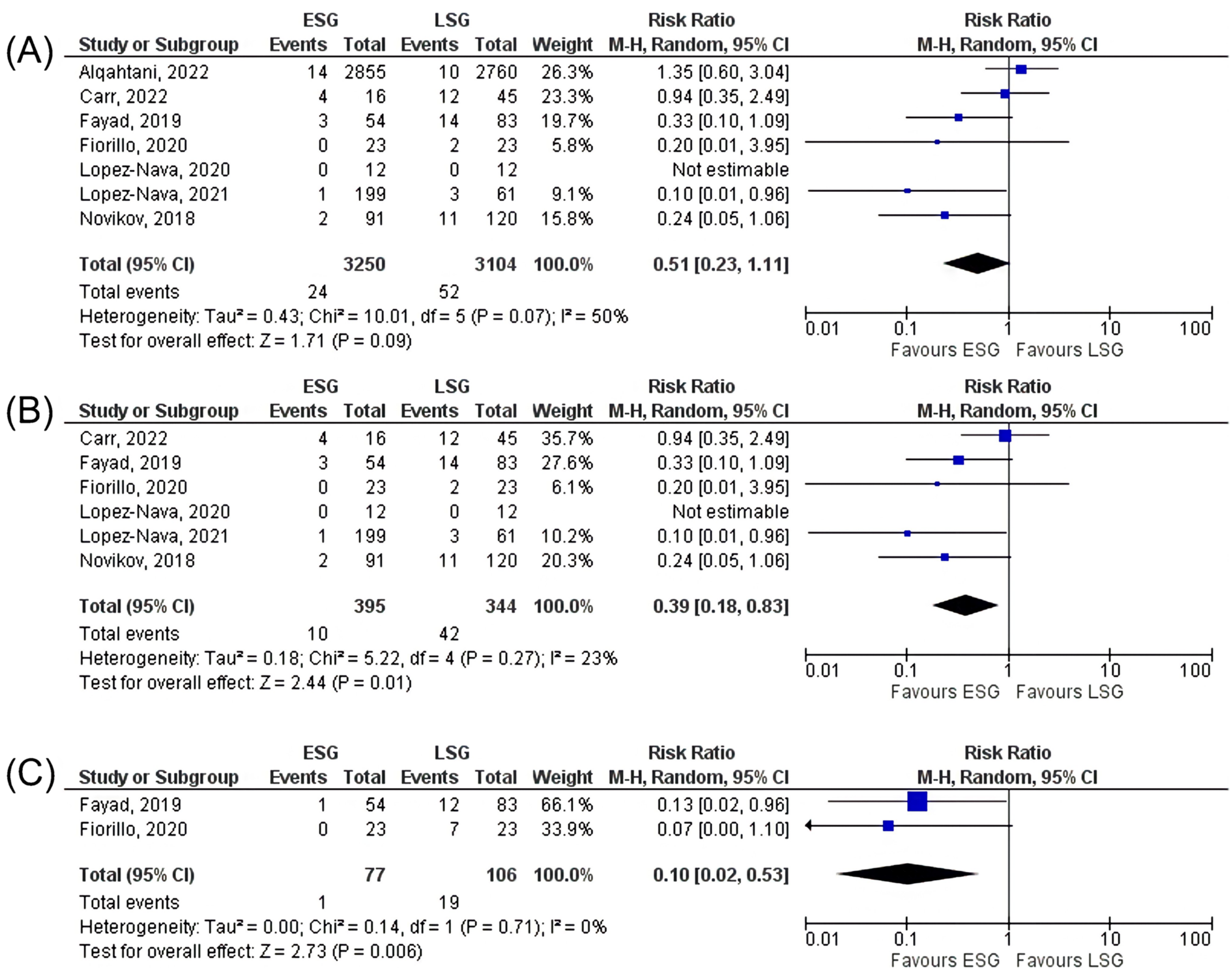

Fig. 4 Forest plots comparing between endoscopic sleeve gastroplasty and laparoscopic sleeve gastrectomy regarding: **A** overall adverse events and **C** gastroesophageal reflux disease. **B** Leave-one-out sensitivity analysis for overall adverse events by excluding Alqahtani et al.

lifestyle intervention, concurrent pharmacotherapy, and year of publication. For instance, Alqahtani et al. [20] had a lower baseline BMI and age when compared with other study cohorts, while patient characteristics between the two groups in the study by Novikov et al. [30] were different. Third, the included studies were mostly conducted in tertiary-care referral centers limiting generalizability. Fourth, we could not analyze the long-term efficacy beyond 24 months due to limited reported data. More comparative prospective studies with longer follow-up data are needed to compare the long-term weight loss efficacy of ESG vs. LSG. Lastly, publication bias assessment was not feasible due to the small number of included studies, limiting assessment of the certainty of the evidence.

In conclusion, in patients with obesity, ESG achieved clinically adequate but lower short- and mid-term weight loss when compared to LSG, with trends of a lower incidence of adverse events. ESG was associated with lower new-onset GERD compared to LSG. ESG could be considered an alternative treatment for patients with lower BMI (class I and II obesity) who are poor candidates or unwilling for standard bariatric surgeries. Further prospective studies, preferably RCTs, are needed to compare the long-term weight loss and safety outcomes of ESG vs. LSG.

Supplementary Information The online version contains supplementary material available at https://doi.org/10.1007/s11695-022-06254-y.

Declarations

Ethics Approval and Consent to Participate This article does not contain any studies with human participants or animals performed by any of the authors. For this type of study, formal consent is not required.

Conflict of Interest Barham K. Abu Dayyeh: consulting for Endogenex, Endo-TAGSS, Metamodix, and BFKW; consultant and grant/research support from USGI, Spatz Medical, Boston Scientific; speaker roles with Olympus, Johnson and Johnson; speaker and grant/research support from Medtronic, Endogastric solutions; and research support from Apollo Endosurgery, Cairn Diagnostics, Aspire Bariatrics. All other authors (Azizullah Beran, Reem Matar, Veeravich Jaruvongvanich, Babusai B. Rapaka, Abdullah Alalwan, Ray Portela, and Omar Ghanem) do not have conflicts of interest to disclose.

References

1. Cawley J, Meyerhoefer C. The medical care costs of obesity: an instrumental variables approach. J Health Econ. 2012;31:219–30.
2. Flegal KM, Carroll MD, Kit BK, et al. Prevalence of obesity and trends in the distribution of body mass index among US adults, 1999–2010. JAMA. 2012;307:491–7.
3. World Health Organization. Obesity and overweight. Available at: https://www.who.int/news-room/fact-sheets/detail/obesity-and-overweight. Accessed December 6, 2019.
4. Pi-Sunyer X. The medical risks of obesity. Postgrad Med. 2009;121:21–33.
5. Cochrane AJ, Dick B, King NA, et al. Developing dimensions for a multicomponent multidisciplinary approach to obesity management: a qualitative study. BMC Public Health. 2017;17:814.
6. A pathway to endoscopic bariatric therapies. Surg Obes Relat Dis. 2011;7:672–82.
7. English WJ, DeMaria EJ, Brethauer SA, et al. American Society for Metabolic and Bariatric Surgery estimation of metabolic and bariatric procedures performed in the United States in 2016. Surg Obes Relat Dis. 2018;14:259–63.
8. Kheirvari M, Dadkhah Nikroo N, Jaafarinejad H, et al. The advantages and disadvantages of sleeve gastrectomy; clinical laboratory to bedside review. Heliyon. 2020;6:e03496.
9. Qumseya BJ, Qumsiyeh Y, Ponniah SA, et al. Barrett's esophagus after sleeve gastrectomy: a systematic review and meta-analysis. Gastrointest Endosc. 2021;93:343-352.e2.
10. Yeung KTD, Penney N, Ashrafian L, et al. Does sleeve gastrectomy expose the distal esophagus to severe reflux?: a systematic review and meta-analysis. Ann Surg. 2020;271:257–65.
11. Abu Dayyeh BK, Rajan E, Gostout CJ. Endoscopic sleeve gastroplasty: a potential endoscopic alternative to surgical sleeve gastrectomy for treatment of obesity. Gastrointest Endosc. 2013;78:530–5.
12. Abu Dayyeh BK, Acosta A, Camilleri M, et al. Endoscopic sleeve gastroplasty alters gastric physiology and induces loss of body weight in obese individuals. Clin Gastroenterol Hepatol. 2017;15:37-43.e1.
13. Alqahtani A, Al-Darwish A, Mahmoud AE, et al. Short-term outcomes of endoscopic sleeve gastroplasty in 1000 consecutive patients. Gastrointest Endosc. 2019;89:1132–8.
14. Fayad L, Adam A, Schweitzer M, et al. Endoscopic sleeve gastroplasty versus laparoscopic sleeve gastrectomy: a case-matched study. Gastrointest Endosc. 2019;89:782–8.
15. Hedjoudje A, Abu Dayyeh BK, Cheskin LJ, et al. Efficacy and safety of endoscopic sleeve gastroplasty: a systematic review and meta-analysis. Clin Gastroenterol Hepatol. 2020;18:1043-1053.e4.
16. Mohan BP, Asokkumar R, Khan SR, et al. Outcomes of endoscopic sleeve gastroplasty; how does it compare to laparoscopic sleeve gastrectomy? A systematic review and meta-analysis. Endosc Int Open. 2020;8:E558–65.
17. Jalal MA, Cheng Q, Edye MB. Systematic review and meta-analysis of endoscopic sleeve gastroplasty with comparison to laparoscopic sleeve gastrectomy. Obes Surg. 2020;30:2754–62.
18. Marincola G, Gallo C, Hassan C, et al. Laparoscopic sleeve gastrectomy versus endoscopic sleeve gastroplasty: a systematic review and meta-analysis. Endosc Int Open. 2021;9:E87-e95.
19. Carr P, Keighley T, Petocz P, et al. Efficacy and safety of endoscopic sleeve gastroplasty and laparoscopic sleeve gastrectomy with 12+ months of adjuvant multidisciplinary support. BMC Prim Care. 2022;23:26.
20. Alqahtani AR, Elahmedi M, Aldarwish A, Abdurabu HY, Alqahtani S. Endoscopic gastroplasty versus laparoscopic sleeve gastrectomy: a noninferiority propensity score-matched comparative study. Gastrointest Endosc. 2022;96(1):44–50. https://doi.org/10.1016/j.gie.2022.02.050.
21. Lopez-Nava G, Asokkumar R, Bautista-Castaño I, et al. Endoscopic sleeve gastroplasty, laparoscopic sleeve gastrectomy, and laparoscopic greater curve plication: do they differ at 2 years? Endoscopy. 2021;53:235–43.
22. Page MJ, McKenzie JE, Bossuyt PM, et al. The PRISMA 2020 statement: an updated guideline for reporting systematic reviews. BMJ. 2021;372:n71.
23. Stroup DF, Berlin JA, Morton SC, et al. Meta-analysis of observational studies in epidemiology: a proposal for reporting. Meta-analysis of observational studies in epidemiology (MOOSE) group. JAMA. 2000;283:2008–12.
24. Luo D, Wan X, Liu J, et al. Optimally estimating the sample mean from the sample size, median, mid-range, and/or mid-quartile range. Stat Methods Med Res. 2018;27:1785–805.
25. Borenstein M, Hedges LV, Higgins JP, et al. A basic introduction to fixed-effect and random-effects models for meta-analysis. Res Synth Methods. 2010;1:97–111.
26. Higgins JP, Thompson SG, Deeks JJ, et al. Measuring inconsistency in meta-analyses. BMJ. 2003;327:557–60.
27. Stang A. Critical evaluation of the Newcastle-Ottawa scale for the assessment of the quality of nonrandomized studies in meta-analyses. Eur J Epidemiol. 2010;25:603–5.
28. Fiorillo C, Quero G, Vix M, et al. 6-Month gastrointestinal quality of life (QoL) results after endoscopic sleeve gastroplasty and laparoscopic sleeve gastrectomy: a propensity score analysis. Obes Surg. 2020;30:1944–51.
29. Lopez-Nava G, Negi A, Bautista-Castaño I, et al. Gut and metabolic hormones changes after endoscopic sleeve gastroplasty (ESG) vs. laparoscopic sleeve gastrectomy (LSG). Obes Surg. 2020;30:2642–51.
30. Novikov AA, Afaneh C, Saumoy M, et al. Endoscopic sleeve gastroplasty, laparoscopic sleeve gastrectomy, and laparoscopic band for weight loss: how do they compare? J Gastrointest Surg. 2018;22:267–73.
31. Sullivan S, Kumar N, Edmundowicz SA, et al. ASGE position statement on endoscopic bariatric therapies in clinical practice. Gastrointest Endosc. 2015;82:767–72.
32. Sinclair P, Brennan DJ, le Roux CW. Gut adaptation after metabolic surgery and its influences on the brain, liver and cancer. Nat Rev Gastroenterol Hepatol. 2018;15:606–24.
33. Khidir N, Al Dhaheri M, El Ansari W, et al. Outcomes of laparoscopic gastric greater curvature plication in morbidly obese patients. J Obes. 2017;2017:7989714–7989714.
34. Dayyeh BA, Rizk M, El-Mohsen MA, et al. Laparoscopic greater curvature plication (LGCP) vs. endoscopic sleeve gastroplasty (ESG): similar efficacy with different physiology. Surg Obes Relat Dis. 2017;13:S205.