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Review article

Resleeve for failed laparoscopic sleeve gastrectomy: systematic review and meta-analysis

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Abstract Despite excellent long-term results, insufficient weight loss, weight regain, and pathologic gastroesophageal reflux disease may require revisional procedures after laparoscopic sleeve gastrectomy (LSG). Resleeve gastrectomy (ReSG) for failed LSG, has been proposed as an alternative to more complex malabsorptive procedures. The aim of this systematic review and meta-analysis was to examine the current evidence on the therapeutic role and outcomes of ReSG for failed LSG. PubMed, EMBASE, and Web of Science data sets were consulted. A systematic review and Frequentist meta-analysis were performed. Ten studies published between 2010 and 2019 met the inclusion criteria for a total of 300 patients. The age of the patient population ranged from 20 to 66 years old and 80.5% were females. The elapsed time between the LSG and ReSG ranged from 9 to 132 months. The estimated pooled prevalence of postoperative leak and overall complications were 2.0% (95% confidence interval [CI] = .5%–4.7%) and 7.6% (95%CI = 3.1%–13.4%). The estimated pooled mean operative time and hospital length of stay were 51 minutes (95%CI = 49.4–52.6) and 3.3 days (95%CI = 3.13–3.51). The postoperative follow-up ranged from 12 to 36 months and the estimated pooled mean percentage excess weight loss was 61.46% (95%CI = 55.9–66.9). The overall mortality ranged from 0% to 2.2%. ReSG after failed LSG seems feasible and safe with acceptable postoperative leak rate, overall complications, and mortality. The effectiveness of ReSG in term of weight loss seems promising in the short-term but further studies are warranted to explore its effect on patients' quality of life, postoperative gastroesophageal reflux disease, and long-term weight loss. (Surg Obes Relat Dis 2020; ■:1–9.) © 2020 American Society for Bariatric Surgery. Published by Elsevier Inc. All rights reserved.

Key words: Laparoscopic sleeve gastrectomy; Resleeve gastrectomy; Leak; Overall complications; %EWL

Laparoscopic sleeve gastrectomy (LSG) has rapidly become popular worldwide for the treatment of morbid obesity because technically straightforward and easy to perform with a demonstrated safety and efficacy [1,2]. Moreover, compared with more complex weight loss surgical procedures, LSG is associated with reduced postoperative dumping syndrome, marginal ulcers, malabsorption, and internal hernia with improved quality of life [3,4].

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Despite LSG long-term follow-up results are excellent, insufficient weight loss, weight regain, and pathologic gastroesophageal reflux disease (GERD) may require revisional procedures in up to 30% of patients [5,6]. Roux-en-Y gastric bypass (RYGB), duodenal switch, or single-anastomosis duodeno-ileal bypass have been proposed as successful malabsorptive procedure [7]. Resleeve gastrectomy (ReSG) is a relatively new surgical option for failed LSG, proposed as an alternative to more complex malabsorptive procedures [8]. However, published studies are few while evidence is limited and puzzled.

The aim of this systematic review and meta-analysis was to examine the current evidence on the therapeutic role and outcomes of ReSG for failed LSG.

Methods

Search strategy

A systematic review was performed according to the guidelines from the preferred reporting items for systematic reviews and meta-analyses checklist (PRISMA) [9] and Meta-analyses of Observation Studies in Epidemiology (https://www.editorialmanager.com/jognn/account/MOOSE.pdf). Institutional review board approval was not required. An extensive literature search was conducted by 3 independent authors (A.A., G.B., J.M.) to identify the English-written published series on ReSG after failed LSG. Web of Science, PubMed, and Embase data sets were consulted matching the terms "re-sleeve gastrectomy," "revised sleeve gastrectomy," and "repeat sleeve gastrectomy" with "AND" and "OR." The references of each article were assessed to complete the research.

Inclusion and exclusion criteria

The inclusion criteria we as follows: (1) outcomes reporting for ReSG after failed LSG; (2) English written; (3) papers with the longest follow-up or the largest sample size in case of articles published by the same study group or based on the same data set. Exclusion criteria were as follows: (1) not English-written; (2) no clear methodology; (3) articles not reporting any of the a priori defined primary outcomes; and (4) articles with <10 patients (Fig. 1).

Data extraction

Three authors (A.A., J.M., G.M.) independently extracted data from eligible studies. Data extracted included study characteristics (first author name, year, and journal of

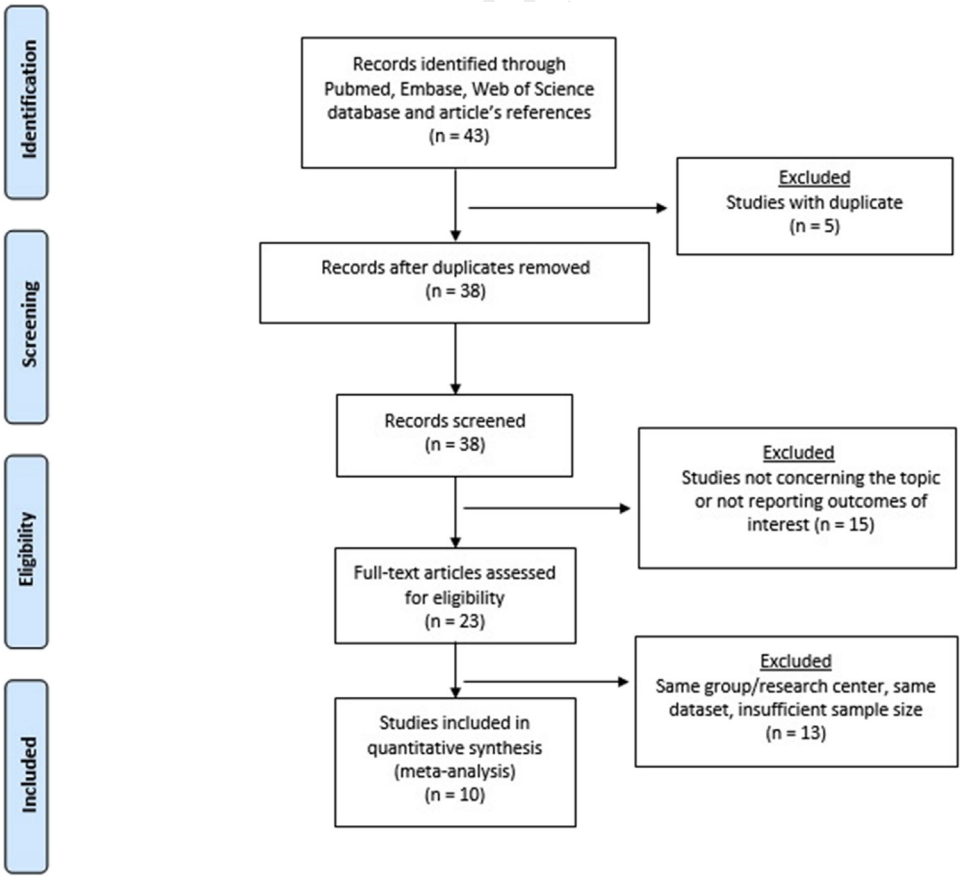

Fig. 1. The preferred reporting items for systematic reviews and meta-analyses checklist (PRISMA) diagram.

publication), number of patients included in the series, time frame, clinical and demographic characteristics of patients' population, type of surgical procedure, and postoperative outcomes. Disagreements between authors were resolved by consensus; if no agreement could be reached, a fourth senior author (D.B.) made the decision.

Quality assessment

Three investigators (A.A., G.B., G.L.) independently assessed the methodologic quality of the papers using the Newcastle-Ottawa Scale [10]. Each study is judged on a "star system" based on the selection of the study groups and the ascertainment of outcome of interest. Each study could earn a maximum of 9 stars. Studies with low-quality score (Newcastle-Ottawa Scale <6) were excluded.

Outcomes

The primary outcomes were postoperative leak and overall complications. The secondary outcomes were operative time (min), hospital length of stay (d), and percentage excess weight loss (%EWL) at a minimum 12-month follow-up.

Statistical analysis

Proportions were transformed via the Freeman-Tukey double arcsine method and with the corresponding back-transformation equation [11,12]. Then an inverse-variance weighted random effects Frequentist meta-analysis was performed by conventional methods using DerSimonian-Laird estimator for estimate between-study variance (τ^2) [13]. Clopper-Pearson 95% confidence interval (CI) for individual were computed [14]. Heterogeneity among the studies was evaluated by I^2 index and Cochran Q test [15]. Heterogeneity was categorized as low, moderate, and high I^2 values of 25%, 50%, and 75% [16]. Small study and publication bias effects were assessed by trim and fill funnel plot visual inspection and Egger tests [17,18]. Prediction interval for treatment effect of a new study is calculated according to Borenstein et al. [19]. As sample size is not the same in all studies, we gradually removed small sample size to perform a sensitivity analysis to assess stability of results. Two-sided P value were considered statistically significant when $< .05$. All analyses and graphic representations were carried out using R version 3.2.2 software [20].

Results

Systematic review

Ten studies published between 2010 and 2019 met the inclusion criteria (Fig. 1). The total number of patients was 300; the sample size of the individual studies ranged from 11 to 61. All reports were observational, cohort studies; each study earned a Newcastle-Ottawa Scale score of 7 or 8 (median 7.3), suggesting a good quality level. Demographic, clinical, and operative variables of the patient sample are shown in Table 1. Three papers included >40 patients. The age of the included patients ranged from 20 to 66 years old and the majority were females (80.5%). Patients co-morbidities were reported in 6 articles while the American Society of Anesthesiologists physical status classification was not reported in any of the included articles. The time between the LSG and ReSG ranged from 9 to 132 months and the indications for ReSG were insufficient weight loss, weight regain, or GERD. The body mass index (BMI) before ReSG ranged from 28.9 to 53.3 kg/m^2 and % EWL after LSG ranged from 13.3% to 77.9%.

All patients underwent laparoscopic ReSG with 3 patients requiring conversion to open surgery for adhesions. The operative time ranged from 30 to 390 minutes with 29 patients that underwent concomitant posterior cruroplasty for hiatus hernia. No intraoperative complications occurred. All articles reported postoperative complications; postoperative morbidity ranged from 0% to 14.7%. Staple-line leak and bleeding were the 2 most commonly reported complications. The overall mortality ranged from 0% to 2.2%. The hospital length of stay ranged from 1 to 63 days. All studies reported the postoperative follow-up that ranged from 12 to 36 months. Postoperative patients' BMI and %EWL were reported in all studies and ranged from 20.3 to 46.3 kg/m^2 and from 18% to 127.2%, respectively. Cost analysis, quality of life evaluation, and postoperative GERD assessment was not reported in any of the included studies.

Meta-analysis

Primary outcomes. In addition to a systematic review we performed a Frequentist meta-analysis. Considering random effect model, the estimated pooled prevalence of postoperative leak resulting from 10 studies (300 patients), is 2.0% (95%CI = .5-4.7%) (Fig. 2A). The prediction lower and upper limits are .0% and 15.3%, respectively. The heterogeneity index is moderate (I^2 = 47.3%, 95%CI = .0%–74.6%; P = .047). Funnel plot does not show evidence of publication bias according to the Egger test (P = .780) (Fig. 2 B). The sensitivity analysis show that omitting Nedelcu et al. [3] study, the heterogeneity decreased to low (24.3%) and the pooled prevalence rise to 3.6% (95%CI = 1.1%–6.9%).

The estimated pooled prevalence of overall complications resulting from 10 studies (300 patients), is 7.6% (95%CI = 3.1%–13.4%) (Fig. 3A). The prediction lower and upper limits are .0% and 27.0%, respectively. The heterogeneity index is moderate (I^2 = 52.9%, 95%CI = 3.70%–77.0%; P = .024). Funnel plot does not show evidence of publication bias according to the Egger test (P = .582) (Fig. 3B). The sensitivity analysis shows the robustness of the results.

Table 1
Demographic characteristics and clinical data of 300 patients undergoing ReSG for failed LSG

Author	Number of patients	Age, yr	F/M	BMI, kg/m^2 pre-ReSG	Time from LSG, mo	Operative time, min	Leak	Overall complications	Mortality	Follow–up, mo	BMI post ReSG	%EWL post ReSG
Iannelli et al. (2010) [21]	13	40.3 ± 13	11/2	34.9 ± 3.1	27.3 (14–82)	43 ± 7.5	0	0	0	12	27.5	71.4
Cesana et al. (2014) [22]	11	40.6 ± 10.2	8/3	38.9 ± 3.8	21.1 ± 9.7	55.8 ± 29.1	0	0	0	12	32.2 ± 3.9	56.8 ± 12.4
Silecchia et al. (2014) [8]	19	nr	17/2	36.5 (32–52)	38.7 (12–80)	nr	2 (11)	5 (26)	0	24	28.8 (23–41.9)	53.4
Nedelcu et al. (2015) [3]	61	40.8	54/7	39 (29–70)	37.4 (9–80)	39 ± 10	0	1 (2)	0	19.9	29.8 (20–41)	62.7 ± 29.2
AlSabah et al. (2016) [23]	24	35	20/4	42	nr	nr	0	0	0	12	34	57.6
Nett et al. (2016) [24]	17	nr	nr	39.8 ± 5.3	63.1 ± 20.3	107 ± 83	1 (6)	6 (35)	0	37.2 ± 7.1	33.8 ± 7.3	53.1 ± 18.3
Rebibo et al. (2018) [25]	46	47.5 ± 15.5	35/11	41.2 ± 5.3	73 ± 33.9	97.6 ± 25	5 (11)	7 (15)	1 (2.2)	22 (12–84)	32.1 ± 5.4	62.3 ± 18.2
Antonopulos et al. (2019) [26]	61	48 ± 11	48/13	40.5 (29–53)	41.5 (10–106)	103 (60–205)	5 (8)	9 (15)	1 (1.6)	12	31.6 (18.8–46)	69.5 (24–125)
Mehmet (2019) [27]	21	37.4 ± 9.6	14/7	46.1 ± 4.3	32.5	48 (37–65)	0	2 (10)	0	12	24.5	86.8
Filip et al. (2019) [28]	27	42 ± 11.5	21/6	35.7 ± 7.0	61.6 (6–132)	157 ± 74.69	0	1 (4)	0	36	27.65 ± 5.13	85.41

ReSG = resleeve gastrectomy; LSG = laparoscopic sleeve gastrectomy; F = female; M = male; BMI = body mass index; %EWL = percentage excess weight loss; nr = not reported.

Values are reported as mean ± standard deviation, median (range), and number (percentage).

Secondary outcomes

The estimated pooled mean operative time resulting from 8 studies (257 patients), is 51 minutes (95%CI = 49.4–52.6) (Fig. 4 A). The prediction lower and upper limits are 14.2 and 143.7, respectively. The heterogeneity index is high (I^2 = 98.9%, $P < .01$). The estimated pooled hospital length of stay resulting from 9 studies (281 patients), is 3.3 days (95%CI = 3.13–3.51) (Fig. 4 B). The prediction lower and upper limits are 1.95 and 5.4, respectively. The heterogeneity index is high (I^2 = 69.4%, $P < .01$). The estimated pooled %EWL at a minimum of 12-month follow-up resulting from 5 studies (196 patients), is 61.46% (95%CI = 55.9–66.9) (Fig. 4C). The prediction lower and upper limits are 42.5% and 80.4%, respectively. The heterogeneity index is high (I^2 = 71.9%, $P < .01$). The sensitivity analysis for operative time and hospital length of stay show the robustness of the results. The sensitivity analysis for %EWL shows that omitting the study by Antonopulos et al. [26], the heterogeneity decreased to low (31.7%).

Discussion

This systematic review and meta-analysis show that ReSG after LSG performed for insufficient weight loss, weight regain, or GERD is feasible and safe with acceptable postoperative leak rate, overall complications, and mortality. Moreover, the effectiveness of ReSG at 1-year minimum follow-up is promising with noteworthy %EWL.

LSG is considered to be a technically straightforward procedure and the surgical technique has been shown to be a main determinant of the procedure success. Particularly, the entire removal of the gastric fundus with the systematic visualization of the left diaphragm crus is a technical key point [29]. The problem of insufficient weight loss, weight regain, and pathologic GERD after LSG are important issues [2,3]. Possible explanations for LSG failure include loss of restriction and changes in dietary habits as well as dilation or incorrect calibration of the stomach, and incomplete resection of the gastric fundus [3,8,30]. For LSG, the correlation between gastric dilation and weight regain is source of debate and evidence is still lacking [31,32]. Therefore, incomplete removal of the gastric fundus seems to be the most reliable hypothesis causing weight regain and postoperative pathologic GERD [2,3].

Revisional bariatric surgery after LSG is becoming more common because the increasing popularity of bariatric surgery and the concomitant rapid increase of LSG as initial treatment option for morbid obesity [23]. Currently, there is a paucity of data and the choice of the most suitable revisional procedure after LSG is debated. Some authors advocate LRYGB as standard revisional procedure after LSG

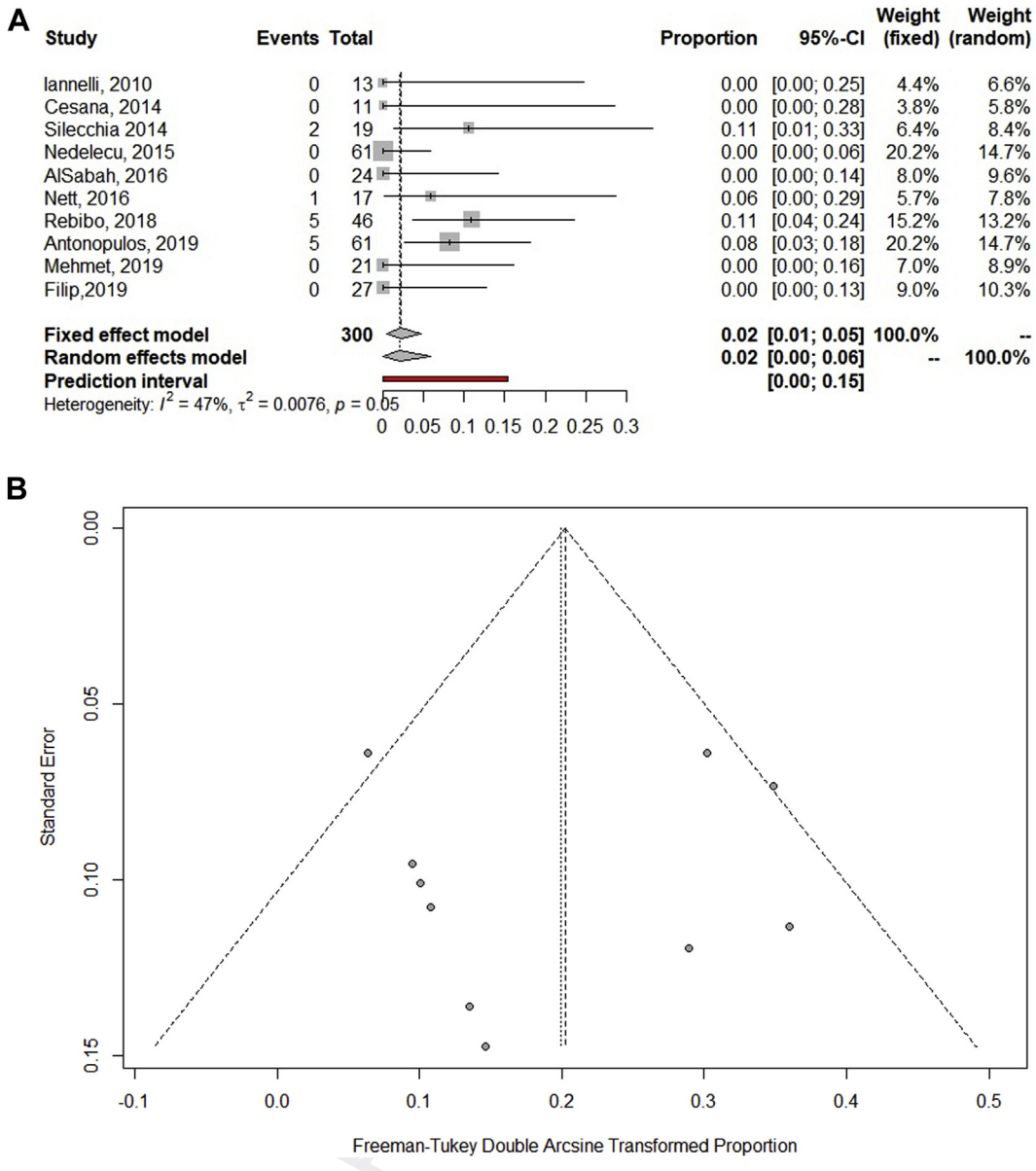

Fig. 2. Forest (A) and funnel (B) plot of postoperative leak.

while other propose duodenal switch or single-anastomosis duodeno-ileal [33]. The recent systematic review of the ASMBS Revision Task Force, suggest the conversion to laparoscopic RYGB in case of severe GERD post-LSG refractory to proton pump inhibitor therapy [34]. All these procedures are feasible and effective options however, patients should be added to strict follow-up programs and should be advised of the risk of malabsorption [3]. ReSG, first described by Gagner et al. [35] in 2003, has been proposed as a feasible revisional option after failed LSG; however, its safety, effectiveness and efficacy in term of weight loss are still debated. ReSG is not malabsorptive and seems associated with shorter operative time, reduced gastric volume, decreased gastric output, lessen dumping syndrome, reduced risk of anemia, osteoporosis, and protein/vitamin deficiency [3].

In our systematic review and meta-analysis, ReSG was associated with an acceptable estimated pooled prevalence of postoperative leak of 2.0% (95%CI = .5%–4.7%). Notably, the upper 95%CI limit was 4.7% and related heterogeneity was moderate (I^2 = 47.3%, P = .047). The sensitivity analysis showed that removal of Nedelcu et al. [3] study contributed to a reduction of related heterogeneity to low values (I^2 = 24.3%). Similarly, the pooled prevalence of overall complications was 7.6% (95%CI = 3.1%–13.4%) with a moderate related heterogeneity (I^2 = 52.9%, P = .024). It is interesting to observe that the estimated pooled prevalence of postoperative leak and overall complications

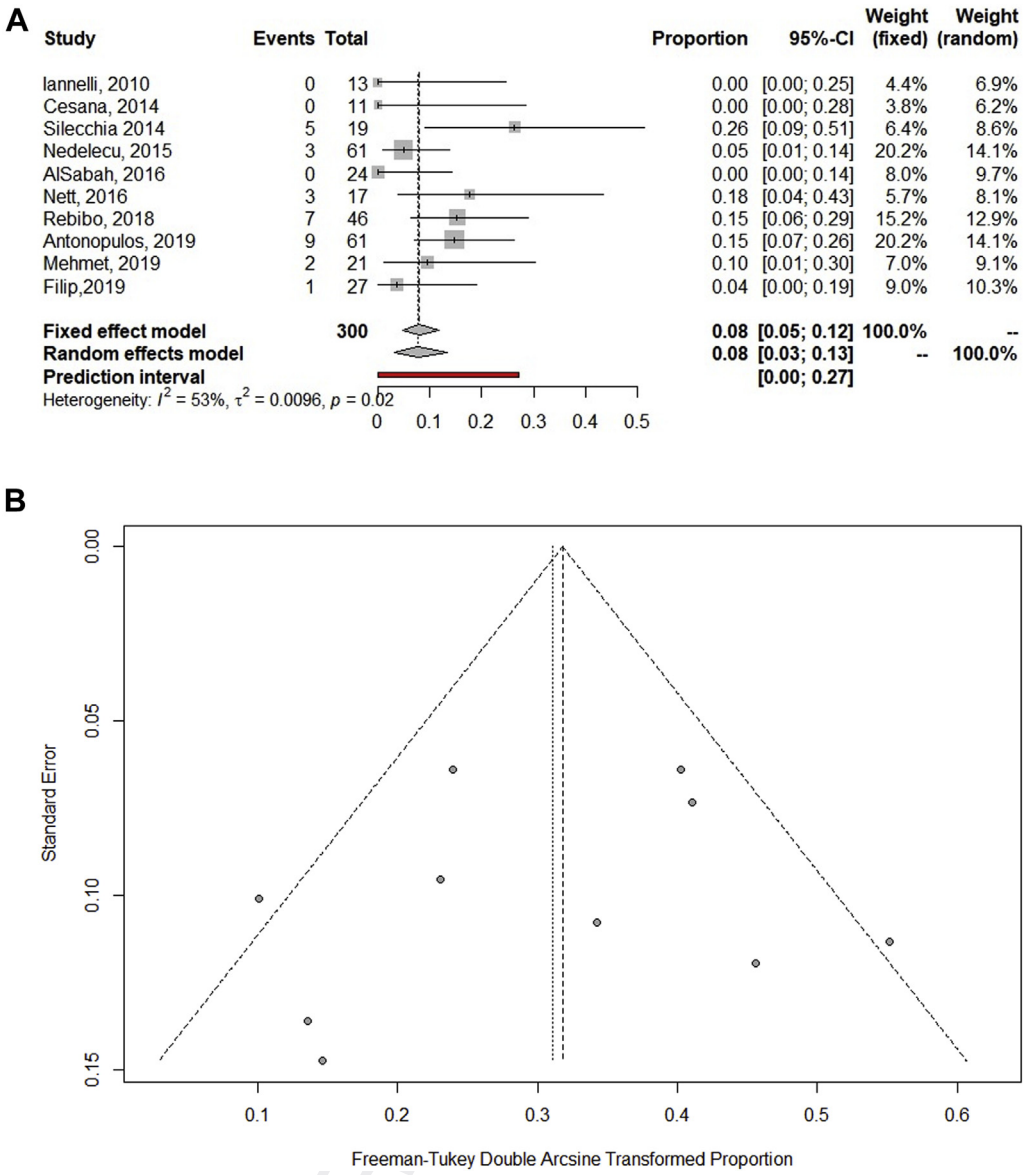

Fig. 3. Forest (A) and funnel (B) plot of overall complications.

seem equivalent to other studies reporting leak and overall complications rate after primary LSG [1,3,36,37]. However, caution is mandatory while interpreting these results because the moderate heterogeneity potentially influenced by diverse surgical technique, surgeons' experience, preoperative gastric volumetry, outcomes reporting, definition of postoperative complications, preoperative co-morbidities, and patients' selection bias.

The pooled mean operative time and hospital length of stay were 51 minutes (95%CI = 49.4–52.6) and 3.3 days (95%CI = 3.13–3.51) with high and moderate related heterogeneity (98.9% and 69.4%, respectively). Again, this may be explained by several factors, such as patients' age, co-morbidities, preoperative BMI, surgical technique, hospital volume, presence of peritoneal adhesions, and surgeons' expertise. Finally, the mean pooled %EWL at 1-year minimum follow-up was 61.46% (95%CI = 55.9–66.9) with a high related heterogeneity (71.9%) that decrease in the sensitivity analysis after removing the study by Antonopulos et al. [26] to moderate levels (31%). Again, these results should be interpreted with caution because different etiology of failure, compliance with dietary regimens, different bougie size, and limited follow-up that do not allow to draw conclusive and robust evidence on over 1-year weight loss effectiveness. In attempt to explore medium-term follow-up data Filip et al. [28] reported data for 27 patients that concluded the 3-year follow-up analysis. The reported BMI and %EWL were

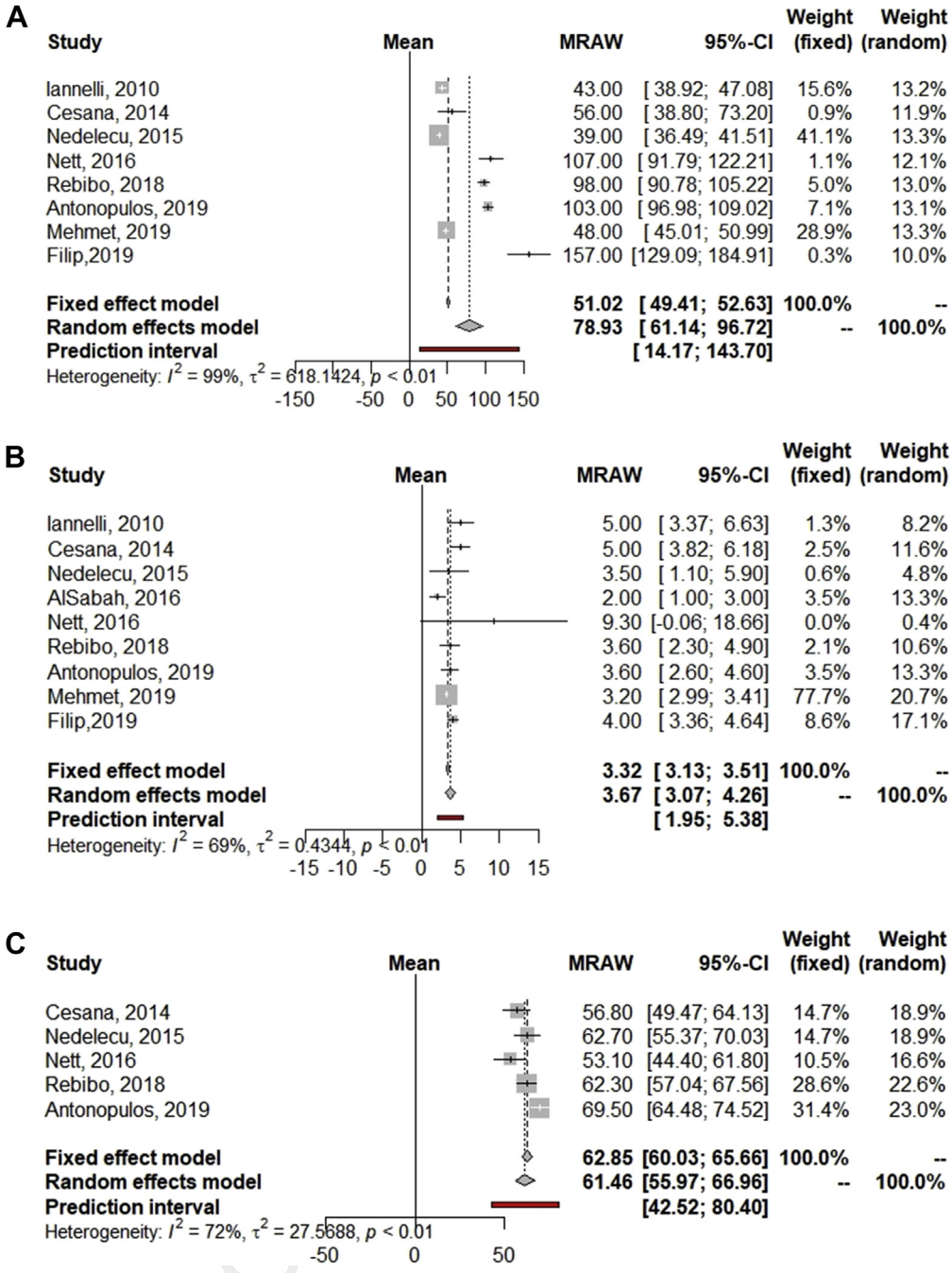

Fig. 4. Forest plot of operative time (min) (A), hospital length of stay (d) (B), and percentage excess weight loss (%EWL) (C).

27.6 ± 5 and 85.4 ± 43.9, respectively. However, the authors failed to report data for GERD-related symptoms. In another study by De Angelis et al. [38], 15 patients were followed up and completed the 4-year postoperative evaluation. The authors reported disappointing results with 9 patients suffering from pathologic GERD requiring conversion to laparoscopic RYGB (5 patients), and weight regain in other 2 patients that were converted to biliopancreatic diversion with duodenal switch. Therefore, authors failed to report data on postoperative BMI and %EWL in a narrow patient sample. Finally, a recent paper reporting data at 5-year follow-up (26 patients) concluded that ReSG is well-tolerated bariatric procedure with low long-term complication rate and favorable results particularly in nonsuper-obese patients (BMI <50) and for primary dilation [39].

We acknowledge this review does have some limitations related to possible publication bias due to exclusion of non-English articles, and heterogeneity of some of the

studies included. In addition, the reason for why patient had this particular surgical approach is not reported and may represent some selection bias. Finally, the limited patient cohort may constitute a further limitation. However, it should be noted that ReSG is a relatively new procedure with few published studies and limited patients' cohorts. The inclusion of observational study could be considered a study limitation; however, excluding observational studies in systematic reviews a priori is inappropriate and internally inconsistent with an evidence-based approach [40]. According to Cochrane guidance, we did not analyze publication bias because there were <10 studies for each comparison, thus publication bias cannot be excluded [41]. To our knowledge, this is the first systematic review and meta-analysis with the purpose to investigate the current evidence on the therapeutic role and outcomes of ReSG after failed LSG in agreements with PRISMA guidelines. Despite the limited number of included studies and patients, the present study adds pooled quantitative evidence to what is already known by excluding small studies (<10 patients) with the intent to limit the potential negative effect of the learning curve (i.e., complications rate overestimation). Because of the lack of conclusive evidence, ReSG may be a practical option for failed LSG and may be adopted according to surgeons' preference, expertise, and patients' preoperative variables. However, the limited follow-up and heterogeneity for some of the considered outcomes, do not allow to draft definitive and robust conclusions. Finally, overall costs analysis, quality of life, and postoperative GERD evaluation mandates further investigations. Prospective and randomized trials are necessary to further explore the medium- to long-term effect of ReSG and deeply compare outcomes with LRYGB/duodenal switch in the setting of revisional surgery after LSG.

Conclusions

This systematic review and meta-analysis shows that ReSG after LSG performed for insufficient weight loss, weight regain, or GERD seems feasible and safe with acceptable postoperative leak rate, overall complications, and mortality. The effectiveness of ReSG in term of weight loss seems promising in the short term but further studies are warranted to explore its effect on patients' quality of life, postoperative GERD, and long-term weight loss.

Disclosures

Q3 *The authors have no commercial associations that might be a conflict of interest in relation to this article.*

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