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ORIGINAL CONTRIBUTIONS

# Indications and Outcomes of Conversion of Sleeve Gastrectomy to Roux-en-Y Gastric Bypass: a Systematic Review and a Meta-analysis

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## Abstract

**Purpose** Sleeve gastrectomy (SG) is the most performed bariatric procedure. Conversion to Roux-en-Y gastric bypass (RYGB) for SG-related complications such as gastroesophageal reflux disease (GERD), insufficient weight loss (ISWL), and weight regain (WR) is increasing. Our aim was to investigate the safety, efficacy, and outcomes of conversion from SG to RYGB.

**Methods** A literature search was performed from database inception to May 2020. Eligible studies must report indications for conversion, %total body weight loss (%TWL), and/or complications. The pooled mean or proportion were analyzed using a random-effects model.

**Results** Seventeen unique studies (n = 556, 68.7% female, average age at time of conversion 42.6 ± 10.29 years) were included. The pooled conversion rate due to GERD was 30.4% (95% CI 23.5, 38.3%; $I^2$ = 63.9%), compared to 52.0% (95% CI 37.0, 66.6%; $I^2$ = 85.89%) due to ISWL/WR. The pooled baseline BMI at conversion was 38.5 kg/m$^2$ (95% CI 36.49, 40.6 kg/m$^2$; $I^2$ = 92.1%) and after 1 year was 32.1 kg/m$^2$ (95% CI 25.50, 38.7 kg/m$^2$; $I^2$ = 94.53%). The pooled %TWL after 1 year was 22.8% (95% CI 13.5, 32.1%; $I^2$ = 98.05%). Complication rate within 30 days was 16.4% (95% CI 11.1, 23.6%; $I^2$ = 57.17%), and after 30 days was 11.4% (95% CI 7.7, 16.7%; $I^2$ = 0%).

**Conclusion** This meta-analysis showed that conversion from SG to RYGB is an option for conversion at a bariatric care center that produces sufficient weight loss outcomes, and potential resolution of symptoms of GERD. Further indication-based studies are required to obtain a clearer consensus on the surgical management of patients seeking RYGB following SG.

**Keywords** Conversion · Revisional · Sleeve gastrectomy · Gastric bypass

**Key Points**
1) Conversion to Roux-en-Y gastric bypass from sleeve gastrectomy–related complications continues to increase.
2) Conversion from RYGB to SG produces sufficient weight loss outcomes and potential resolution of symptoms of GERD.
3) Post-conversion complications were frequently observed.

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## Introduction

Obesity rates across the globe have nearly tripled since 1975. In 2016, the World Health Organization estimated that 39% of the world's adult population were overweight, and approximately 13% were obese [1]. Currently, there is significant evidence suggesting that, of all treatment modalities, bariatric surgery is the most effective intervention with regard to long-term weight-related complications, comorbidities, and mortality rates [2, 3]. In recent years, the sleeve gastrectomy (SG) has become the most common surgical approach for the treatment of morbid obesity [4]. SG was initially introduced as a first step bridging procedure for duodenal switch (DS) [5, 6]. It has been shown to induce effective and durable weight loss outcomes and reduce morbidity and mortality rates, as well as being less technically demanding for surgeons [4, 7–9].

According to 2018 estimates from the American Society for Metabolic and Bariatric Surgery, SG was the most common weight loss operation in the USA, being utilized in 59.3% of all bariatric procedures [10].

However, despite its popularity and success, long-term studies have highlighted potential complications associated with SG [9, 11]. A subset of patients could experience weight loss failure, defined as insufficient weight loss (IWL) or weight recidivism (WR). Weight recidivism refers to the regain of lost weight over time, an especially prevalent issue with SG and one that imposes health risks to patients through the recurrence of obesity-related comorbidities. A previous systematic review showed that the incidence of weight recidivism after SG ranged from 5.7% at 2 years to 75.6% at 6 years [12]. Another large multicenter study reported a 35.1% significant weight regain rate at 5 years after SG [13]. Furthermore, de novo or worsening of pre-existing gastroesophageal reflux disease (GERD) has been increasingly reported after SG [14, 15]. A previous systematic review demonstrated a 19% prevalence of post-op GERD after SG in 10,718 patients, and an incidence of de novo GERD after SG of approximately 23% [16]. In addition, there have been some limited reports of Barrett's esophagus after SG [17, 18]. SG could disrupt the anti-reflux barrier between the stomach and the lower esophagus. This may become problematic for a subset of patients who fail to respond to conservative management, such as proton pump inhibitors (PPIs), warranting further intervention.

For both subsets of patients, a revisional conversion procedure is often required. In a previous systematic review, RYGB was reported as the most common conversion procedure following SG [19]. Therefore, we sought to investigate the safety and efficacy of indication-based conversion of SG to RYGB.

## Methods

### Data Sources and Search Strategies

A comprehensive search of several databases from inception to May 19, 2020, was conducted in compliance with the Preferred Reporting Items for Systematic Reviews and Meta-analyses (PRISMA) guidelines [20]. The databases included Ovid MEDLINE(R) and Epub Ahead of Print, In-Process & Other Non-Indexed Citations and Daily, Ovid Embase, Ovid Cochrane Central Register of Controlled Trials, Ovid Cochrane Database of Systematic Reviews, and Scopus. The search strategy was designed and conducted by an experienced librarian with input from the study's principal investigator. Controlled vocabulary supplemented with keywords was used to search for studies describing conversion from sleeve gastrectomy to Roux-en-Y gastric bypass. The actual strategy listing all search terms used and how they are combined is available in Supplementary Item 1.

### Eligibility Criteria and Quality Assessment

Eligible studies must meet all of the following inclusion criteria: (1) participants must be adults older than or equal to 18 years who underwent RYGB as a revisional surgery following SG-related complication or weight regain; (2) indication for the conversion must be reported; and/or (3) percent total weight loss (%TWL) or excess loss (%EWL) and/or adverse events must be reported after completion of treatment. Case reports, conference abstracts and/or abstracts, and articles that were not reported in English were excluded from the study. The quality of each study was independently evaluated by two authors (RM and AB) using the National Institutes of Health (NIH) quality assessment [21]. Results of the quality assessment of all included studies are shown in Supplementary Item 2. Weight regain and insufficient weight loss were defined per study in Supplementary Item 3.

### Statistical Analysis

The pooled means and proportions of our data were analyzed using a random-effects model, generic inverse variance method of DerSimonian and Laird, which assigns the weight of each study based on its variance [22]. The heterogeneity of effect size estimates across the studies was quantified using the Q statistic and $I^2$ ($P < 0.10$ was considered significant). A value of $I^2$ of 0–25% indicates insignificant statistical heterogeneity, 26–50% low heterogeneity, and 51–100% high heterogeneity [23]. Data analysis was performed using Open Meta analyst software (CEBM, Brown University, Providence, RI, USA).

## Results

### Study Selection and Characteristics

A total of 1254 records were identified from the initial search of electronic databases. After the exclusion of duplicated articles, 980 articles underwent title and abstract review. Following the exclusion of articles that did not fulfill the eligibility criteria, 25 articles underwent a full-length review. Eight articles were further excluded, with reasons shown in Supplementary Item 4. Finally, 17 articles (n = 556, 68.7% female) met our eligibility criteria and were included in this meta-analysis [24–40]. The mean age at the time of conversion ranged from 34 to 50 years, and the mean body mass index (BMI) at the time of conversion ranged from 33.3 to 48.3 kg/m$^2$. The studies included in this meta-analysis did not report mean time until conversion per indication. The baseline characteristics of the included studies are comprehensively described in Table 1.

**Table 1** Baseline characteristics of included studies

| Study | Publication Year | Subjects underwent RYGB (n) | Mean Age of Subjects (years) | Female patients (n); (%) | Conversion due to GERD (n) | Conversion due to IWL/WR (n) | Mean BMI Before /at SG (kg/m$^2$) | Mean BMI Before/at RYGB conversion (kg/m$^2$) | Mean Time interval from SG to RYGB conversion (months) | Mean follow up Time (months) |
|---|---|---|---|---|---|---|---|---|---|---|
| Landreneau et al. [24] | 2018 | 89 | 47.2 | 70; (79%) | 17 | 11 | NA | 43.2 | 19 | 15 |
| Iannelli et al. [25] | 2016 | 40 | 40.2 | 31; (77.8%) | 11 | 29 | 47.5 | 39.3 | 32.6 | 18.6 |
| Boru et al. [26] | 2018 | 30 | 41 | 23; (76.6%) | 15 | 12 | 46.9 | 36 | 33 | 24 |
| Barajas-Gamboa et al. [27] | 2019 | 47 | 39 | 36; (76.5%) | 21 | NA | NA | 34 | 36 | 17 |
| Nevo et al. [28] | 2017 | 23 | 45.3 | 12; (52%) | NA | 23 | NA | 41.6 | 39 | 24 |
| Quezada et al. [29] | 2016 | 50 | 39 | 42; (84%) | 16 | 28 | 36.4 | 33.8 | 49 | 36 |
| Poghosyan et al. [30] | 2016 | 34 | 47.8 | 26; (76.5%) | 3 | 31 | 53.3 | 44.7 | 32 | 36 |
| Carmeli et al. [31] | 2015 | 10 | 45.8 | 7; (70%) | NA | 10 | 44.5 | 40 | 36.2 | 15.6 |
| Gautier et al. [32] | 2012 | 18 | 40.9 | NA | 6 | 9 | 55 | 40.9 | 23.8 | 15.5 |
| Parmar et al. [33] | 2017 | 22 | 51 | 15; (68%) | 10 | 11 | 45.8 (GERD); 53.1 (IWL/WR) | 36.9 | NA | 16 |
| Al Sabah et al. [34] | 2016 | 12 | 34 | 10; (83%) | NA | 12 | 52 | 48.3 | NA | 12 |
| Yorke et al. [35] | 2017 | 18 | 41.7 | 14; (77.8%) | 3 | 9 | 50.5 | 43.1 | 41.8 | 21.1 |
| Yilmaz et al. [36] | 2017 | 9 | 37.3 | 6; (66.6%) | 6 | 3 | NA | NA | NA | 13.5 |
| Van Wezenbeek et al. [37] | 2016 | 68 | 44.7 | 17; (25%) | 11 | 15 | 49.3 | 36.1 | NA | 24 |
| Langer et al. [38] | 2010 | 8 | 35.75 | 4; (50%) | 3 | 5 | 46.94 | NA | 33 | 25.5 |
| Casillas et al. [39] | 2016 | 48 | 44 | 46; (96%) | 14 | 11 | 45.9 | 36.8 | 26 | 24 |
| Abdemur et al. [40] | 2016 | 30 | 50.3 | 23; (76%) | 9 | 7 | 40.7 | 33.3 | 43.6 | 18.3 |

Abbreviations: *NA*: not available; *IWL*: Insufficient Weight Loss; *WR*: Weight Regain; SG: Sleeve Gastric surgery; *RYGB*: Roux-en-Y gastric bypass surgery; *BMI*: body mass index; *GERD*: Gastroesophageal reflux disease; *n*: Number

## Indications of RYGB Conversion

Among the included studies, indications for conversion of SG to RYGB included GERD, IWL/WR, dysphagia, gastric stenosis, fistula formation, gastric torsion, type II diabetes, mechanical complications, and two-planned bariatric procedures. These 3 primary studies performed the planned two-stage procedure conversion from SG to RYGB for those with high operative risk and high BMI [24, 35, 37]. This was a measure used to induce some weight loss with SG followed by RYGB. These studies' definitions of their two-stage procedure are described in Supplementary Item 5. GERD and IWL/WR were considerably the most frequently reported indications for conversion. The indication for conversion due to GERD was 30.4% (95% CI 23.5, 38.3%; $I^2$ = 63.9%), while the indication for conversion due to ISWL/WR was 52.0% (95% CI 37.0, 66.6%; $I^2$ = 85.89%) (Fig. 1). Gastric stenosis, torsion, and mechanical complications were not categorized due to the different criteria in each study. Statistical analysis was not conducted because there were not enough studies to calculate the pooled rate. However, the frequency of these complications per study has been described in Supplementary Item 6.

## Weight-Related Outcomes

The pooled baseline BMI at conversion was 38.5 kg/m$^2$ (95% CI: 36.49, 40.6 kg/m$^2$; $I^2$= 92.1%), and after one year was 32.1 kg/m$^2$ (95% CI: 25.50, 38.7 kg/m$^2$; $I^2$= 94.53%) (Fig. 2). The %TWL was reported at 6 months follow-up in 3 studies [29, 30, 36] and 12 months follow-up in 4 studies [24, 29, 30, 37]. The pooled mean %TWL after completion of treatment was 25.2% (95% CI: 12.8, 37.5%; $I^2$ = 99.12%) at 6 months and 22.8% (95% CI: 13.5, 32.1%; $I^2$ = 98.05%) at 12 months.

For the specific indication of IWL/WR, a total of 2 studies [24, 33] reported a %EWL of 40.0% (95% CI: 23.71, 56.37%; $I^2$ = 86.06%) at 12 months.

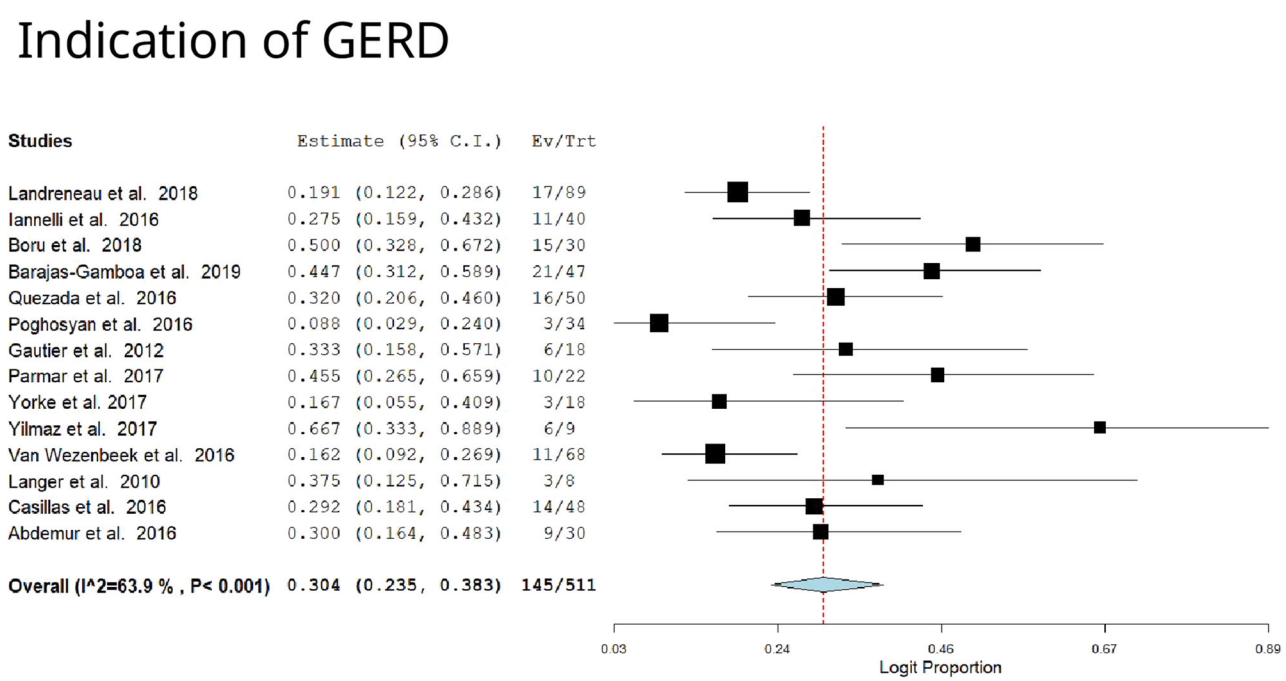


**Fig. 1** Forest plot of indications of conversion from SG to RYGB due to GERD or ISWL/WR

## Resolution of Comorbidities

Following the conversion procedure, several comorbidities were reportedly resolved. At 1-year follow-up post RYGB, GERD resolution was 79.7% (95% CI: 59.6, 91.3%; $I^2$ = 22.29%, 4 studies), type II diabetes resolution was 57.7% (95% CI: 36.9, 76.1%; $I^2$ = 0%, 3 studies), and hypertension resolution was 49.4% (95% CI: 25.8, 73.3%; $I^2$ = 0%, 2 studies) (Fig. 3). In addition, at 2-year follow-up post RYGB, GERD resolution was 91.3% (95% CI: 64.4, 98.4%; $I^2$ = 56.98%, 2 studies) and type II diabetes resolution was 37.7% (95% CI: 12.4, 72.0%; $I^2$ = 0%, 2 studies). The descriptions of the reported comorbidities, based on individual studies, are comprehensively described in Table 2.

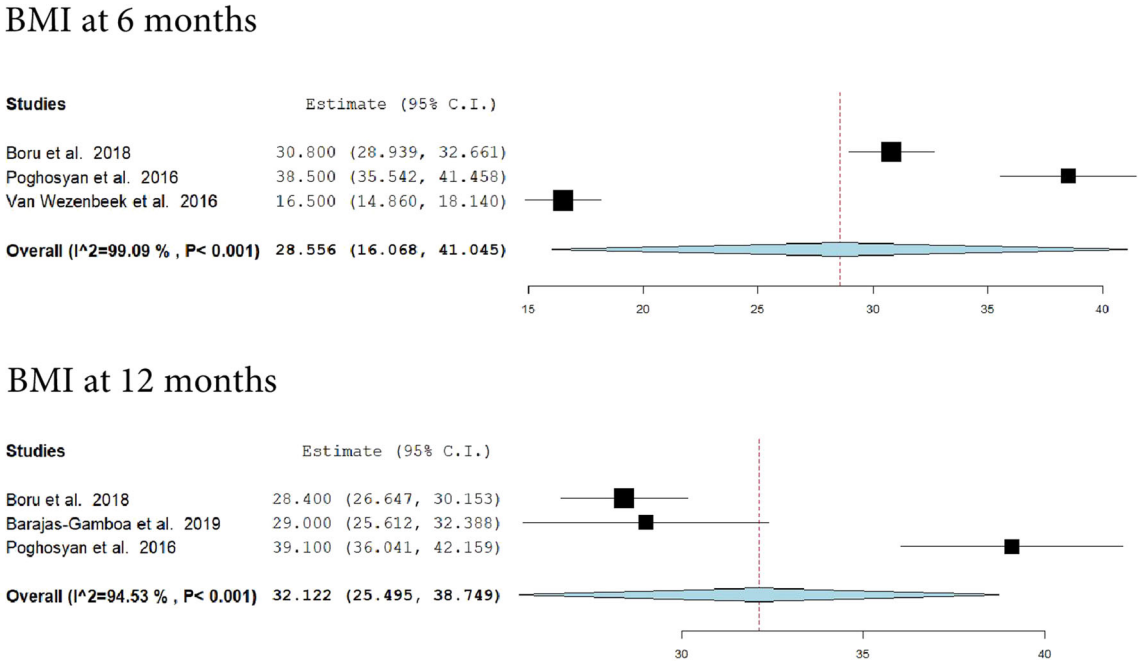


**Fig. 2** Forest plot of BMI at 6 and 12 months following conversion

## Adverse Events

Regarding the safety of RYGB following SG, there were no deaths reported. The pooled serious adverse event rate within 30 days was 16.4% (95% CI: 11.1, 23.6%; $I^2$ = 57.17%), while the pooled adverse event rate after 30 days was 11.4% (95% CI: 7.7, 16.7%; $I^2$ = 0%). Median re-operation rate for complications post-conversion was 6.7% (range 4–13%). All adverse events were summarized in Table 3.

## Discussion

Though SG is an effective tool against obesity and has gained much popularity in recent years, a subset of patients could develop complications, mainly GERD and IWL/WR that may warrant revisional surgery. Our meta-analysis, thereby, was conducted with an aim to provide the totality of available evidence on the safety and efficacy of RYGB revision of SG.

The conversion of SG to RYGB has been very frequently reported in the literature for a variety of indications including IWL/WR, GERD, stenosis, leaks, dysphagia, gastric outlet obstruction, and persistent diabetes [41–46]. Based on a meta-analysis by Guan et al., the rate of revisional surgery following SG was approximately 10.4%. When subcategorized, Guan and colleagues showed that the pooled rate for ISWL as an indication for revision was 11.8%, while for GERD was 3.2% [47]. In line with previous studies [33], the most frequent SG-related complications requiring revisional surgery were GERD and IWL/WR that accounted for 30.4% and 52.0% of the conversions.

With regard to GERD following SG, some patients suffer from persistent or worsening GERD symptoms, and others report "de novo" symptoms of GERD [48]. For this group of patients, especially those who do not respond to conservative medical treatment, a conversion to RYGB is well established as an effective option for the control of their symptoms [48]. This falls in line with the findings in our analysis, in which the resolution of GERD symptoms at 1-year follow-up was 79.7% and at 2-year follow-up was 91.3%. However, we must also consider the lack of objective post-operative tests, such as 24-h pH monitoring and manometry, in these studies. Cessation of medication use, self-reporting of symptom improvement, and questionnaires were the only reported forms of identifying post-operative GERD resolution within the included studies. Hence, further studies using objective measures of assessing GERD are needed [49]. In addition, longer term studies (≥ 5 years) after conversion to RYGB are required to adequately assess GERD resolution and requirement for medical therapy, especially in light of new data suggesting increased risk of esophageal dysmotility after RYGB [50].

For the indication of IWL/WR, the literature remains inconclusive as to which revisional surgery provides the most holistically optimal outcomes. Re-sleeve (endoscopic or surgical), fundectomy, biliopancreatic diversion with duodenal switch (BPD/DS), SADI-S (single anastomosis duodeno–ileal bypass), or mini gastric bypass-one anastomosis gastric bypass (MGB/OAGB) can be alternative revisional approaches for post-SG patients [51, 52]. Our analysis suggests

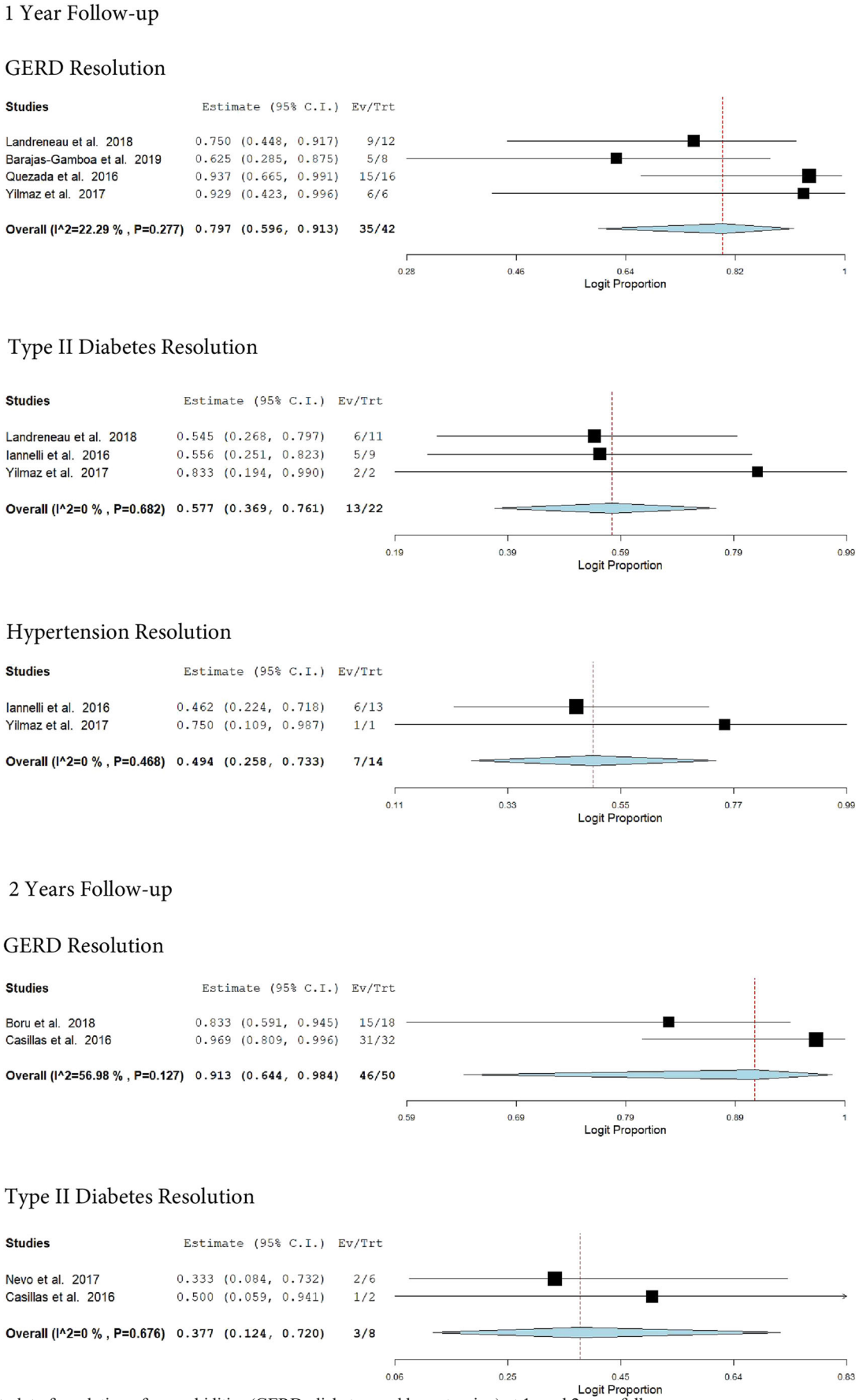


**Fig. 3** Forest plot of resolution of comorbidities (GERD, diabetes, and hypertension) at 1- and 2-year follow-up

**Table 2** Descriptions of the reported comorbidities based on individual studies

| | Length of follow-up (months) | Diabetes II | | | Hypertension | | | ǂ GERD | | |
|---|---|---|---|---|---|---|---|---|---|---|
| | | Total N | Improved | Resolved | Total N | Improved | Resolved | Total N | Improved | Resolved |
| *Landreneau et al. [24] | 12 | 16 | 2 | 4 | NA | NA | NA | 17 | NA | 9 |
| Iannelli et al. [25] | 18.6 | 9 | 5 | NA | 13 | 4 | 6 | 11 | NA | 11 |
| Boru et al. [26] | 24 | NA | NA | NA | NA | NA | NA | 18 | NA | 15 |
| **Barajas- Gamboa et al. [27] | 12 | 6 | NA | NA | 8 | NA | NA | 29 | NA | 5 |
| Nevo et al. [28] | 24 | 6 | NA | 2 | 9 | NA | 4 | NA | NA | NA |
| Quezada et al. [29] | 12 | NA | NA | NA | NA | NA | NA | 16 | 5 | 10 |
| Poghosyan et al. [30] | 36 | 11 | 7 | NA | 13 | 13 | NA | 9 | NA | 9 |
| Carmeli et al. [31] | 19 | 4 | 3 | 1 | 3 | 2 | NA | NA | NA | NA |
| Gautier et al. [32] | 15.5 | 3 | 1 | 2 | NA | NA | NA | 6 | NA | 6 |
| Parmar et al. [33] | 16 | 5 | 2 | 3 | 13 | 8 | 4 | 10 | 2 | 8 |
| Yorke et al. [35] | 21.1 | 5 | NA | 4 | 4 | NA | 4 | 4 | NA | 3 |
| Yilmaz et al. [36] | 12 | 2 | NA | 2 | 1 | NA | 1 | 6 | NA | 6 |
| Langer et al. [38] | 14 | NA | NA | NA | NA | NA | NA | 3 | NA | 3 |
| Casillas et al. [39] | 24 | 2 | 1 | 0 | NA | NA | NA | 32 | 31 | NA |
| Abdemur et al. [40] | 18.3 | NA | NA | NA | NA | NA | NA | 9 | NA | 6 |

Abbreviations: *NA* not available; *n* Number of patients; *GERD* Gastroesophageal reflux disease

Study Article Al Sabah et al. [34] and Van Wezenbeek et al. [37] Did not provide resolution of co-morbidities information

*Landreneau et al. [24] 5 Diabetic patients and 5 GERD patients, were lost in follow up

**Barajas- Gamboa et al. [27] 21 GERD patient was lost to follow up

ǂ GERD as an indication for conversion based on the GERD cohort

that conversion from SG to RYGB yielded effective weight loss outcomes on the specific indication of IWL/WR demonstrating that the weight loss outcome for this particular subset of patients was %EWL of 40.0% at 12 months follow-up. It has previously been demonstrated that BPD/DS provided better weight loss outcomes than RYGB (median %EWL 59% vs 53% at 34 months), but with a higher risk of short-term complications and severe vitamin deficiencies [42]. Re-operation rate (less than 30 days) and readmission rate (more than 30 days) were higher in BP/DS patients in comparison to RYGB patients (11% vs 6% and 9% vs 0%, respectively) [42]. As such, patients seeking further weight loss following an initial SG warrant careful consideration by a multi-disciplinary surgical team comfortable with offering a spectrum of revisional options and tailoring the revisional choice to the patient's clinical and pathophysiologic presentation rather than technical comfort with a particulate revisional approach.

Post-operative serious complication rates following revisional RYGB were 16.4% and 11.4%, within and after 30 days of follow-up, respectively. These rates are similar to those found in other studies evaluating outcomes of revisional RYGB [53] and are comparable to alternative revisional procedures. Previous studies have reported complication rates ranging from 10.2 to 16.7% following re-sleeve gastrectomy [51, 54, 55] and 25% following revisional DPD/DS [42]. Although this illustrates that RYGB following SG is a relatively safe procedure, it is still worthwhile to consider that revisional procedures in general pose a higher risk of complications in comparison to primary procedures [42]. For RYGB in particular, a case-matched analysis reported a 30-day morbidity of 27% in revisional procedures, compared to 8.1% in primary procedures [56]. As such, it is imperative that clinicians must take these risks into account for consideration of this revisional approach for making an informed decision. Despite its infancy, endoscopic re-sleeve options are being considered a minimally invasive approach for select patients with IWL/WR after SG, given their reasonable short-term efficacy and absence of SAE [57].

There are several limitations in our meta-analysis. Firstly, few studies reported %TWL, which may have compromised the validity of the reported weight loss outcomes in our study. %EWL is known to be a less optimal measure of weight loss since it is dependent on BMI. Similarly, the analysis for the resolution of comorbidities following RYGB consisted of a small sample size, and this consequently warrants further investigation. Additionally, many patients in the included studies were lost to follow-up, and thus, our outcomes were limited to 1 year. Lack of follow-up is a pervasive issue in the field of bariatric surgery [58], so it is understandable that gaps

**Table 3** Adverse events following conversion to RYGB

| | <30 days following conversion | | >30 days following conversion | | Managed through | Reason for Reoperation |
|---|---|---|---|---|---|---|
| | Total (n) | Adverse events | Total (n) | Adverse events | | |
| Landreneau et al. [24] | 28/89 | Superficial SSI (9), Organ space SSI (7), GJ stricture (3), UTI (1), Pulmonary embolism (1), Negative diagnostic laparoscopy (2) Other (5) | NA | NA | Re-Operation on (6), Conservative (22/89) | Negative diagnostic laparoscopy (2), Open repair of GJ anastomotic leak (1), Open resection of small bowel enterotomy (1), Large bowel obstruction requiring hemicolectomy (1), Open repair of remnant gastrostomy staple line leak (1) |
| Iannelli et al. [25] | 7/40 | GJ stricture (4), Incisional hernia (1), Fever (1), Abdominal pain (1) | NA | NA | NA | NA |
| Boru et al. [26] | 3/30 | Anastomotic leak (1), Proximal Leak (1), Bleeding from jejunal anastomosis (1) | NA | NA | NA | NA |
| Barajas-Gamboa et al. [27] | 4/47 | Superficial SSI (2), anastomotic Leak (1), Gastrointestinal haemorrhage (1) | NA | NA | Re-Operation (2), Conservative (2/47) | Active intraabdominal Bleeding (1), Intraabdominal sepsis (1) |
| Nevo et al. [28] | 3/23 | NA | 4/23 | NA | Re-Operation (3) | Early adhesions and a retained gastric remnant |
| Poghosyan et al. [30] | 4/34 | Gastrojejunostomy Leak (1), Intestinal wound (1), Strangulated hernia at trocar port (1), Abdominal discomfort (1) | 3/34 | Perforated anastomotic ulcer (1), Strangulated hernia at trocar port (1), Abdominal discomfort (1) | Re-Operation (4), Conservative (3/34) | Missed enterotomy inflicted during adhesiolysis (1), GJ leak (1), Intestinal strangulation on trocar port (1), Negative diagnostic laparoscopy (1) |
| Carmeli et al. [31] | NA | NA | 1/10 | Severe peptic ulcerations (1) | NA | NA |
| Gautier et al. [32] | 1/18 | Small bowel injury | NA | NA | Re-Operation (1) | Peritonitis due to a small bowel injury – was re-operated on by laparotomy |
| Parmar et al. [33] | 1/22 | Bowel obstruction (1) | 5/22 | Marginal Ulcer (1), Abdominal pain (1), GERD (1), Abdominal pain with GERD (1) | Re-Operation (1) | Bowel obstruction due to an internal hernia |
| Yorke et al. [35] | 6/18 | Post-operative bleed (1), Marginal Ulcer (2), SSI (3) | NA | NA | Re-Operation (2), Conservative (4/18) | NA |
| Yilmaz et al. [36] | 5/9 | Post- operative Bleeding (1), SSI (2), Gastrojejunostomy anastomosis Stenosis (1), Splenic injury (1) | NA | NA | Re-Operation (1), Conservative (4/9) | Splenic injury conversion to open |
| Van Wezenbeek et al. [37] | 6/68 | Leak (3), Bleeding (3) | NA | NA | NA | NA |
| Langer et al. [38] | 1/8 | Gastrojejunostomy Leak (1) | NA | NA | Conservative (Temporary stent placement) | NA |
| Casillas et al. [39] | 9/48 | Oral intolerance (6), Post-operative Bleeding (2), Shortness of breath (1) | 6/48 | GJ anastamosis stricture (3), Hiatal hernia (1), chronic abdominal pain (1), Gastrocutaneous fistula (1) | Re-Operation (2), Conservative (13/48) | laparoscopic repair of a recurrent hiatal hernia (1), normal laparoscopy for chronic abdominal pain (1) |
| Abdemur et al. [40] | 3/30 | Hematoma at jejunojejunostomy (1), Marginal Ulcer (2) | NA | NA | NA | Surgical evacuation laparoscopically |

Abbreviations: *NA* not available; *SSI* surgical site infection; *UTI* urinary tract infection; *GJ* gastrojejunal

Study Article Quezada et al. [29], and Al Sabah et al. [34], Did not provide Definitions of co-morbidity resolution

in weight loss outcomes increase in proportion to the length of follow-up within these studies. Nevertheless, further studies are needed to determine the long-term benefits of SG to RYGB conversions. Moreover, with regard to the resolution of GERD following conversion, the inconsistency of objective post-operative measurements between studies may have compromised the validity of the findings. Additionally, our analyses did not include enough studies to carry out publication bias assessments, thus limiting our ability to assess the certainty of the evidence. Finally, we attempted to carry out an indication-based comparison of the weight loss outcomes and procedural complications between the two groups (GERD and IWL/WR); however, this was not feasible due to the very limited number of studies that separately pooled the patient outcomes. The indications of GERD and IWL/WR represent two substantially different cohorts of patients with different expectations and weight loss trajectories [33]; thus, it is important for physicians to acknowledge and manage these patients as two separate groups, as this will help holistically tailor the approach to revisional surgery for patients following SG.

In conclusion, this meta-analysis showed that the conversion from SG to RYGB results in sufficient mid-term weight loss and potential resolution of GERD. However, post-conversion complications are more frequently observed than primary RYGB. Further long-term, indication-based studies are required to substantiate this revisional approach in comparison to other endoscopic and surgical options.

**Supplementary Information** The online version contains supplementary material available at https://doi.org/10.1007/s11695-021-05463-1.

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**Author Contribution** RM, NM, and BA conceived and designed the study, reviewed the literature, collected, analyzed, and interpreted the data, and drafted the manuscript. VJ, RS, EV, DM, AB, TK, and OG conceived and designed the study, and critically revised the manuscript. RM, NM, RS, AB, and BA reviewed the literature, collected, analyzed, and interpreted the data, and drafted the manuscript. All authors read and approved the final manuscript.

## Declarations

**Ethics Approval** For this type of study, formal consent is not required.

**Consent to Participate** Informed consent does not apply.

**Conflict of Interest** Dr. Abu Dayyeh is a consultant of USGI, Olympus, Hemostasis, DyaMx, and EndoGastric Solutions. The corresponding author is the recipient of research support from Apollo Endosurgery, USGI, Boston Scientific, and Medtronic. Dr. Abu Dayyeh is a speaker for Medtronic, Olympus, and Johnson and Johnson. All other authors report no conflict of interest.

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