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REVIEW

Gastroesophageal Reflux Disease as an Indication of Revisional Bariatric Surgery—Indication and Results—a Systematic Review and Metanalysis

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Abstract

This systematic review evaluates the indications and results of revisional bariatric surgery (RBS) in gastroesophageal reflux disease (GERD). A systematic literature search and meta-analysis was performed for articles published by April 1, 2021. After examining 722 papers involving 17,437 patients, 48 studies were included ($n=915$ patients). RBS for GERD was mostly reported after sleeve gastrectomy ($n=796$, 87%) and one anastomosis gastric bypass ($n=62$, 6.8%) and was performed due to intractable GERD (71.6%), GERD and weight issues (16%), and biliary reflux (6.2%). Mean follow-up of the studies was 31.5 (3–84) months. Pooled estimation of a meta-analysis of studies reported 7% of GERD following primary surgery needing RBS, in which 99% of the patients experienced remission.

Keywords GERD · Acid reflux · Bile reflux · Alkaline reflux · Primary bariatric surgery · Revisional bariatric surgery

Abbreviations

BMS	Bariatric metabolic surgery
GERD	Gastroesophageal reflux disease
SG	Sleeve gastrectomy
OAGB	One anastomosis gastric bypass
RYGB	Roux-en-Y gastric bypass
RBS	Revisional bariatric surgery
BMI	Body mass index
GB	Gastric banding
PRISMA	Preferred Reporting Items for Systematic Reviews and Meta-Analyses
VBG	Vertical banded gastroplasty

Key Points
- SG is the most reported primary bariatric procedure, which needed revisional BMS due to GERD.
- RYGB is the most performed conversional BMS for GERD after primary BMS.
- Secondary bariatric surgery leads to a remission of GERD in 99%.

Introduction

Nowadays, bariatric metabolic surgery (BMS) has an increasingly important role in the treatment of severe obesity since it is the most effective treatment modality for achieving sustained weight loss and improvement

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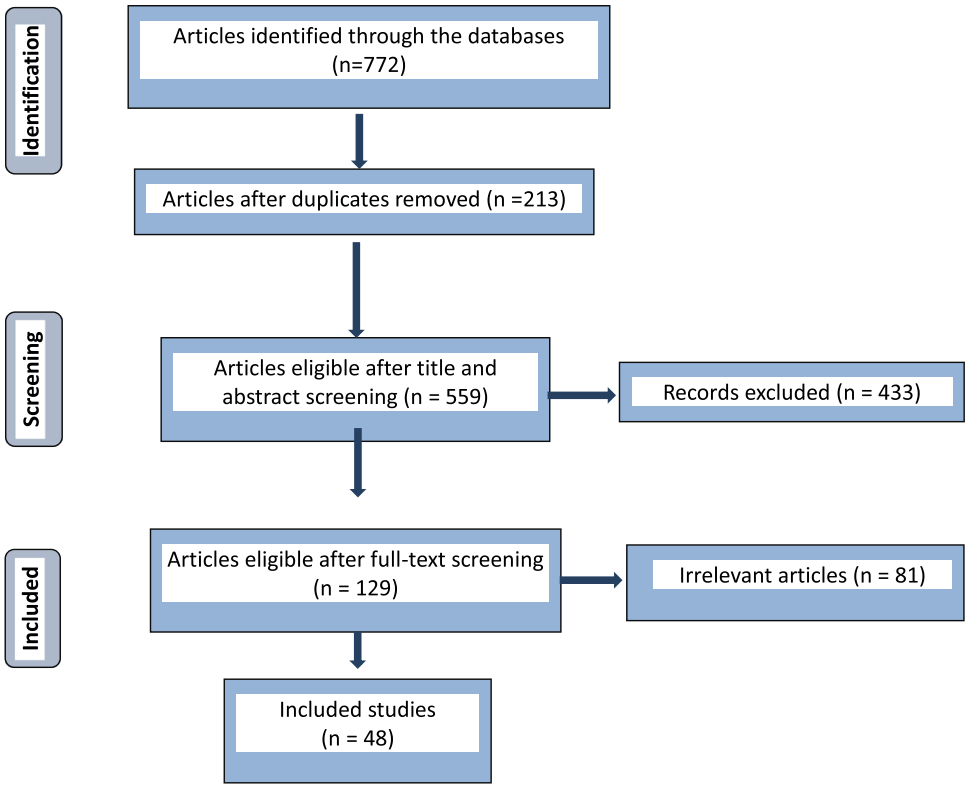

Fig. 1 Preferred Reporting Items for Systematic Reviews and Meta-Analyses

of associated medical problems [1]. The annual number of surgical procedures is increasing every year, with 685,874 bariatric surgeries performed worldwide in 2016 [2]. As more primary procedures are being performed, there is a rise in revisional and conversional surgeries. Insufficient weight loss and complications such as gastroesophageal reflux disease (GERD) following primary surgery are two major indications for revisional or conversional surgery [3].

Weight loss, especially following BMS, effectively improves GERD as well as gastrointestinal and general quality of life in many patients [4, 5]. However, depending on the type of bariatric procedure, surgery can worsen or even cause a new onset of GERD [6]. Indeed, procedures such as sleeve gastrectomy (SG) can cause blunting of the angle of His, hypotension of the lower esophageal sphincter, decreased gastric compliance, and increased intraluminal pressure that could lead to GERD and even Barrett's esophagus [7–9]. Consequently, GERD remains a relevant problem for many bariatric patients, the symptoms of which in many cases cannot be controlled by conservative measures.

Revisional or conversional bariatric surgery for GERD encompasses a wide variety of procedures, which can be complex and technically challenging [10]. Considering the paucity of high-quality published data and that existing revisional/conversional options are numerous and patient-related, there is a lack of surgical standardization or a surgical procedure that is preferred to another to treat GERD after primary BMS. The aim of this study is to provide a systematic review and meta-analysis on GERD after primary BMS and discuss the various procedures available to address this issue.

Methods

This systematic review and meta-analysis was designed based on the Preferred Reporting Items for Systematic Reviews and Meta-Analyses (PRISMA) guidelines [11] and Meta-analysis of Observational Studies in Epidemiology (MOOSE) [12]. This systematic review and meta-analysis was registered in the Prospective Register of Systematic Reviews (PROSPERO) (code number: CRD42021252188).

Search Strategy

PubMed, Web of Science, and Scopus were reviewed for articles published by April 1, 2021. The keywords are "revisional bariatric surgery," "RBS," "conversion," "gastric banding revision," "sleeve gastrectomy

Table 1 Demographic and baseline characteristics

Authors	Design	*N*	GERD	Age	Primary surgery	Interval (months)	Interval to revision	BMI	Revision BMI	Nadir BMI	Nadir BMI before revision	BMI at primary surgery	BMI at revision/ conversion
Abdemur 2016 [15]	Ret	30	9		SG	–	–	42.2	30.5	–	–	42.2 ± 6.4	30.5 ± 2.9
Aguilar-Espinosa 2020 [16]	Ret	420	3	45.4	SG	17.2	17.2 ± 8 months	43.6	26.5	–	–	43.6 ± 4.3	26.5 ± 5.8
Alvarenga 2016 [17]	Ret	5	5	–	SG	–	–	–	–	–	–	–	–
Angrisani 2020 [18]	Ret	91	1	–	SG and HH repair	11	11 months	–	–	–	–	–	–
Angrisani 2015 [19]	Ret	105	2	–	SG and HH repair	36	18–36 months	–	–	–	–	–	–
Arman 2016 [20]	Ret	63	3	–	SG	–	–	–	–	–	–	–	–
Balla 2017 [21]	Ret	12	2	–	SG and HH repair	48	1 and 2 years	–	–	–	–	–	–
Bashah 2020 [22]	Ret	49	2	–	Conversional OAGB (after SG)	–	–	–	–	–	–	–	–
Bellorin 2020 [23]	Ret	51	20	37	SG	19	19 (3–36) months	–	37.9	–	–	–	37.9 ± 7.8
Bolckmans 2018 [24]	Ret	526	6	–	OAGB	–	–	–		–	–	–	–
Boru 2020 [25]	Ret	96	12		SG and HH repair	–	–	–		–	–	–	–
Boru 2018 [26]	Ret	30	15	41	SG and HH repair	33	33 ± 27.8	46.9	36	29.4	29.4 ± 4.4	46.9 ± 6.3	36 ± 9
Der-Ming Chang 2018 [27]	Ret	1759	45	–	SG	33	33 (3–62) months	–	–	–	–	–	–
Chiappetta 2019 [28]	Ret	55	26	46.5	SG	36.5	36.5 ± 22.3 (2–91)	53.4	42.2	48	48 ± 23	53.4 ± 9.5	42.2 ± 8.7
Chopra 2012 [29]	Ret	185	6	–	SG	–	–	–	–	–	–	–	–
Chuffart 2017 [30]	Ret	64	2	–	SG	–	–	–	–	–	–	–	–
Csendes 2019 [31]	Pros	97	6	–	SG	–	–	–	–	–	–	–	–
D'Urso 2021 [32]	Ret	60	24	45	SG	67	5.6 years (2–11)	–	32	–	–	–	32 ± 5.3
El Chaar 2016 [33]	Ret	481	6	46.2	SG	27	27 months (17–41)	45.7	41	–	–	45.7	41
Facchiano 2016 [34]	Case report	1	1	51	OAGB	1	1 month	–	–	–	–	–	–
Felsenreich 2019 [35]	Pros	10	10	49.4	SG	42.7	42.7 ± 14.9	45.1	37.3	–	–	45.1 ± 9.2	37.3 ± 9.2
Frieder 2020 [36]	Ret	77	16	49.1	SG	26.2	26.2 ± 32.7	–	32.6	–	–	–	32.6 ± 7.9
Hussain 2019 [37]	Ret	925	3	44	OAGB	–	–	–	–	–	–	–	–
Iannelli 2016 [38]	Ret	40	11	40.3	SG	42.7	42.7 (16–91)	47	39.8	–	–	47	39.8
Kassir 2020 [39]	Ret	2780	32	45.6	OAGB	30.3	30.3		26	–	–	40.1 (28–57)	26 (21–35)
Kermansaravi 2021 [40]	Ret	12	12	42.08	OAGB	30	30 (12–60) months		26.45	–	–	44.54 ± 3.32	26.45 ± 2.34
Lazzati 2020 [41]	Ret	8051	406	–	SG	–	–	–	–	–	–	–	–
Lee 2011 [42]	Ret	23	3	–	OAGB	–	–	–	–	–	–	–	–
Lim 2019 [43]	Ret	97	14	43.69	SG	36	36 (6–68)	–	41.71	–	–	–	41.71 ± 3.78
Mandeville 2017 [44]	Ret	26	7	–	SG	–	–	–	–	–	–	–	–
McKenna 2014 [45]	Ret	56	21	–	VBG	–	–	–	–	–	–	–	–
Morales 2010 [46]	Ret	26	4	–	RYGB/SG	–	–	–	–	–	–	–	–
Musella 2017 [47]	Ret	61	4	–	OAGB	–	–	–	–	–	–	–	–
Nedelcu 2015 [48]	Pros	61	4	–	SG	–	–	–	–	–	–	–	–
Nimeri 2017 [49]	Case report	1	1	27	OAGB	12	More than 1 year		46	46	46		46

Table 1 (continued)

Authors	Design	*N*	GERD	Age	Primary surgery	Interval (months)	Interval to revision	BMI	Revision BMI	Nadir BMI	Nadir BMI before revision	BMI at primary surgery	BMI at revision/ conversion
Parikh 2008 [50]	Case report	1	1	49	BPD-DS	–	–	55	31	28	28	55	31
Parmar 2017 [51]	Ret	22	10	47.8	SG	–	–	45.8	30.5		–	45.8	30.5
Piazza 2015 [52]	Ret	48	4	–	GB	–	–	–	–	–	–	–	–
Poghosyan 2016 [53]	Ret	34	3	–	SG	–	–	–	–	–	–	–	–
Pok 2016 [54]	Ret	18	8	–	SG	–	–	–	–	–	–	–	–
Quezeda 2016 [55]	Ret	50	16	39.84	SG	49	49 months (24–67)	36.4	33.8	–	–	36.4 (34–40)	33.8 (31–36)
Rayman 2020 [56]	Ret	263	69	44.2	SG	57	5.6 years (1–17)	46.5	40.6	31.4	31.4 ± 6.2	46.5 ± 6–9	40.6 ± 5.9
Scozzari 2010 [57]	Pros	150	3	36.9	VBG	–	–	–	–	–	–	–	–
Seki 2015 [58]	Ret	179	1	40.7	SG	–	–	–	–	–	–	–	–
Ser 2019 [59]	Ret	148	11	34.2	SADJB-SG	–	–	34.2	–	–	–	34.2 ± 5.9	–
Soong 2019 [60]	Ret	28	28	44.1	SG	40.8	40.8 months (6–108)	34.2	–	–	25.7	34.2 ± 5.9	25.7
Srikanth 2011 [61]	Ret	38	11	46	GB and VBG	8	8 ± 5 years	–	–	–	41.4	–	41.4 ± 7.8
Yilmaz 2017 [62]	Ret	32	6	36.7	SG	15.1	15.1 ± 3.3	–	–	–	–	–	–

Ret, retrospective; *Pros*, prospective; *SG*, sleeve gastrectomy; *MGB*, mini-gastric bypass; *VBG*, vertical banded gastroplasty; *SADJB-SG*, single-anastomosis duodenal-jejunal bypass with sleeve gastrectomy; *LSG*, laparoscopic sleeve gastrectomy; *OAGB*, one anastomosis gastric bypass; *RYGB*, Roux-en-Y gastric bypass; *HH repair*, hiatal hernia repair

revision," "gastric bypass revision," "GERD," "gastroesophageal reflux disease," "GERD after bariatric surgery," "GERD after gastric banding," "GERD after sleeve gastrectomy," "GERD after gastric bypass," "bile reflux," "acid reflux," "alkaline reflux," "heart burn," "dysphagia," "esophagitis," "erosive esophagitis," "dyspepsia," "regurgitation," "Barrett´s esophagus," "Barrett esophagus," "hiatal hernia," "sleeve stenosis," "sleeve twist," or a combination of them in the title or abstract. The search strategy can be found in the supplementary files. References of the articles were manually reviewed for additional relevant papers. Duplicate studies were removed.

Eligibility Criteria

Two of the authors independently evaluated the eligibility of papers according to the PRISMA guidelines. Inclusion criteria were studies in English about GERD remission following revisional bariatric surgery as intervention in original studies, case series, or case reports, but only original and case series were added in the meta-analysis. Due to the equal number of case and population, case reports were excluded in the meta-analysis of prevalence by the analytical software. Exclusion criteria were studies with insufficient data or duplication of studies involving the same patient cohort by the same institution with shorter follow-ups and only updated articles were selected.

Data extraction

For data extraction, a structured checklist was used including type of the study, number of patients, age, gender, type of primary surgery (1. GB, 2. SG, 3. RYGB, 4. OAGB, 5. others), interval to revision/conversion in months, BMI in kg/m^2 at primary surgery, nadir BMI before and at revision/conversion, upper endoscopy at primary surgery and revisional surgery (1. GERD A, 2. GERD B, 3. GERD C, 4. GERD D, 5. Hiatal hernia < 3 cm, 6. Hiatal hernia ≥ 3 cm), hiatal hernia repair at primary surgery (yes without mesh, yes with mesh/no), interval of GERD presentation after 1st surgery, type of revisional surgery, reasons of revision (GERD, hiatal hernia, dysphagia, bile reflux, anatomical stricture), clinical presentation, diagnostic tools regarding GERD (upper endoscopy, ph monitoring, esophageal manometry, questionnaire, CT scan), GERD-Q questionnaire, perioperative complications (up to 30 days), last follow-up with BMI and outcome with resolution of GERD (yes/

Table 2 BMI changes and value of quantitative variables

Variables	Minimum	Maximum	Mean	Std. deviation
Age (year)	27	51	42.9	5.5
BMI at primary surgery (kg/m^2)	34.2	55	44.3	6.4
BMI at revision (kg/m^2)	26	46	35.1	6.04
Nadir BMI (kg/m^2)	28	48	36.56	9.63
Nadir BMI before revision (kg/m^2)	25.7	48	35.7	9.19
BMI at last follow-up after revision (kg/m^2)	27.2	33.5	29.37	2.2
Interval between surgery and GERD (month)	1	67	31.23	16.32
Last follow-up (month)	3	84	31.49	23.25

no), and treatment if failure of conversion/revision with final outcome.

Data were retrieved by two independent investigators. The differences observed in this process were corrected by a third independent investigator. The quality of the selected studies was checked by a quality assessment tool for before-after (pre-post) studies with no control groups [13]. Also, the Newcastle Ottawa Quality Assessment Scale (NOS) was used for qualitative assessment of studies [14].

Statistical Analysis

The main measure of effect/effect size was the percent of remission as prevalence (ratio of remission to total GERD case following reoperation). Cochran's test (*Q*-test) (showing significant heterogeneity in the meta-analysis) and I2 (showing the amount of heterogeneity ranged from 0 to 100%.) were used to assess the heterogeneity among the studies. The random-effects model was used for the continuous and frequency outcome under study. Also, a random-effects meta-analysis was applied for estimating the main index, which was the pooled prevalence, at 95% confidence interval. A forest plot was used to present the pooled prevalence. Publication bias was assessed using Begg's tests. The analysis was performed using Stats version 13.

Results

A total of 48 of 772 studies examining 17.437 patients were included in this systematic review and meta-analysis (Fig. 1). Study characteristics, including study design, type of primary surgery, interval to revision, and BMI at different time points, of all patients of the 48 studies included in the meta-analysis are presented in Table 1.

Primary bariatric procedures included SG (27 studies, $n = 764$ patients, 83.5%), SG with hiatal hernia repair (5 studies, $n = 32$ patients, 3.5%), OAGB (8 studies, $n = 62$ patients, 6.8%), single anastomosis duodenal-jejunal bypass with sleeve gastrectomy (SADJB-SG) (1 study, $n = 11$ patients, 1.2%), biliopancreatic diversion with duodenal switch (BPD/DS) (1 study, $n = 1$ patient, 0.1%), vertical banded gastroplasty (VBG) (2 studies $n = 24$ patients, 2.6%), gastric banding (GB) (1 study, $n = 4$, 0.4%), one study included mixed data of RYGB and SG ($n = 4$, 0.4%), and one study included mixed data of GB and VBG ($n = 11$, 1.2%) (Table 1).

In total, 915 patients underwent revisional bariatric surgery (RBS) due to GERD. Mean BMI at primary surgery was 44.3 + / − 6.4 kg/m^2 and 35.1 + / − 6.04 kg/m^2 at revision with an interval between primary surgery and GERD of 31.23 + / − 16.32 months. All quantitative variables such as BMI changes at different times, age,

Table 3 Reasons to do reoperation following primary surgery

Variable	No. of patients reported in studies with listed reasons	Percent
intractable GERD including persistent GERD, de novo GERD	655	71.58
GERD + hiatal hernia	13	1.42
GERD + weight regain/weight loss failure	147	16.06
biliary reflux	57	6.22
GERD + band problems	3	0.32
GERD + stenosis	30	3.27
GERD + Barrett's esophagus	10	1.09

Table 4 Clinical characteristics

Authors	Upper endoscopy at primary surgery	Hiatal hernia repair at primary surgery	Type of revisional surgery	Reasons of revision/conversion	Upper endoscopy at revision	GERD	Hiatal hernia	Dysphagia	Bile reflux	Anatomical stricture/sleeve stenosis	Clinical Presentation	Upper endoscopy	Esophageal manometry	CT	Perioperative complications (up to 30 days)	Outcome with resolution of GERD
Abdemur 2016 [15]	–	–	RYGB	Severe GERD, aspiration pneumonia due to reflux	–	–	–	–	–	–	–	–	–	–	–	Yes (66.6%), if failure: Continue medical therapy
Aguilar-Espinosa 2020 [16]	–	–	RYGB	–	–	–	–	–	–	–	–	–	–	–	–	Yes (100%)
Alvarenga 2016 [17]	–	–	RYGB	Intractable GERD	–	–	–	–	–	–	–	Yes	–	–	N/A	Yes (100%)
Angrisani 2020 [18]	–	–	RYGB	Intractable GERD	–	–	–	–	–	–	–	–	–	–	N/A	–
Angrisani 2015 [19]	–	–	RYGB ± HH repair by mesh	Severe GERD	–	–	–	–	–	–	–	–	–	–	–	–
Arman 2016 [20]	–	–	HH repair, RYGB	Severe GERD, Denovo GERD	–	–	–	–	–	–	–	–	–	–	–	–
Balla 2017 [21]	Hiatal hernia	Yes, HH repair	RYGB	Severe GERD	–	–	–	–	–	–	GERD	–	–	–	–	–
Bashah 2020 [22]	–	–	1 patient converted to RYGB	Biliary Reflux	–	Biopsy-proven reflux esophagitis	–	–	Yes	–	Biliary Reflux	–	–	–	–	–
Bellorin 2020 [23]	GERD	–	RYGB	–	–	–	–	–	–	–	Severe GERD	Yes	–	–	3 (15%)	Yes (85%), if failure: Continue PPI
Bolckmans 2018 [24]	–	–	RYGB	Severe biliary Reflux	–	–	–	–	–	–	Severe GERD	–	–	–	–	–
Boru 2020 [25]	Yes	Yes, HH repair	RYGB ± HH repair by mesh	Persistent/recurrent severe GERD	Yes	Yes		–	–	–	–	Yes		Yes	–	–
Boru 2018 [26]	–	–	RYGB	–	–	Esophagitis, HH repair:8	–	–	–	–	–	Yes	–	–	–	Yes (83%)
Der-Ming Chang 2018 [27]	–	–	HH repair + gastropexy	–	–	–	–	–	–	–	–	–	–	–	–	–

Table 4 (continued)

Authors	Upper endoscopy at primary surgery	Hiatal hernia repair at primary surgery	Type of revisional surgery	Reasons of revision/conversion	Upper endoscopy at revision	GERD	Hiatal hernia	Dysphagia	Bile reflux	Anatomical stricture/sleeve stenosis	Clinical Presentation	Upper endoscopy	Esophageal manometry	CT	Perioperative complications (up to 30 days)	Outcome with resolution of GERD
Chiappetta 2019 [28]	–	–	RYGB + HH repair	Esophagitis ≥ grade B treatment	–	–	–	–	–	–	–	Yes	–	–	Anastomotic ulcer and postoperative ileus	Yes
Chopra 2012 [29]	–	–	RYGB	Refractory GERD	–	–	–	–	–	–	–	–	–	–	–	Yes (100%)
Chuffart 2017 [30]	–	–	RYGB	GERD complicated with esophagitis/de novo GERD	–	–	–	–	–	–	–	–	–	–	–	Yes
Csendes 2019 [31]	–	–	RYGB	Intractable GERD	–	–	–	–	–	–	–	–	–	–	–	–
D'Urso 2021 [32]	–	–	RYGB	GERD + sleeve stenosis/twist associated with GERD)	–	Esophagitis, GERD, esophageal motility disorder, Barrett's esophagus	6 (10%) > 2 cm. 2 (3.3%) < 4 cm	–	–	–	Symptoms were refractory to high dosage of PPI treatment and/or associated with endoscopic signs of esophagitis and disruption of the esophagogastric junction	Yes		Yes		Yes (100%)
El Chaar 2016 [33]	–	–	RYGB	GERD	–	–	–	–	–	–	GERD-related symptoms failed medical treatment	Yes	No	No	–	Yes
Facchiano 2016 [34]	No GERD	–	RYGB	Biliary	Pouchitis and bile reflux	–	–	–	Yes	–	Recurrent heartburns 2 weeks after OAGB	Yes	–	–	No	Yes
Felsenreich 2019 [35]	–	N0	RYGB + HH repair	Barrett's esophagus and reflux	In all patients	Barrett's esophagus	In 2 patients	–	–	–	Symptomatic reflux	Yes	Yes in 6	No	No	Yes
Frieder 2020 [36]	–	–	RYGB, HH repair	GERD	Unresponsive medical treatment	–	In 21 patients	–	–	–	Clinical reflux symptoms with unresponsive medical treatment	Yes	–	Upper gastrointestinal series	–	–

Table 4 (continued)

Authors	Upper endoscopy at primary surgery	Hiatal hernia repair at primary surgery	Type of revisional surgery	Reasons of revision/conversion	Upper endoscopy at revision	GERD	Hiatal hernia	Dysphagia	Bile reflux	Anatomical stricture/sleeve stenosis	Clinical Presentation	Upper endoscopy	Esophageal manometry	CT	Perioperative complications (up to 30 days)	Outcome with resolution of GERD
Hussain 2019 [37]	–	–	2 RYGB, 1 Braun	Biliary reflux	–	Bile reflux with bile gastritis/pouchitid	–	–	Yes	–	Biliary	Yes	No	No	–	–
Iannelli 2016 [38]	–	–	RYGB	GERD	Intractable GERD	–	–	–	–	–	Intractable GERD: reflux symptoms refractory to PPI with endoscopic esophagitis	Yes	No	Yes and upper gastrointestinal series		100%, profound and immediate relief of reflux symptoms
Kassir 2020 [39]	–	–	RYGB (AL 100, BPL 150)	Biliary reflux	–	–	–	–	Yes	–	Invalidating reflux resistant to medical management	Yes	No	Yes	No mortality, 1 Grade III Clavien Dindo, 2 Clavien Dindo II	Symptoms relief in 100% of patients
Kermansaravi 2021 [40]	Yes	N0	RYGB	Biliary reflux	–	GERD A 1. B = 10, C = 12, bile in esophagus = 3	Small 2, moderate 2, large 1	–	Yes	No	Symptomatic reflux	Yes	–	–	–	Symptoms relief in 100% of patients
Lazzati 2020 [41]	–	–	NA	GERD	–	–	–	–	–	–	–	–	–	–	–	–
Lee 2011 [42]	–	–	NA	GERD	–	–	–	–	Yes	–	–	–	–	–	–	–
Lim 2019 [43]	–	–	RYGB	GERD + esophagitis	Esophagitis hiatal hernia	A = 5, B = 7, C = 2	HH repair without mesh	–	–	–	–	Yes	No	4 strictures treated by endoscopic balloon dilatation	Mean follow-up 16 months	–
Mandeville 2017 [44]	–	–	RYGB	GERD	–	–	–	–	–	–	–	–	–	–	–	–
McKenna 2014 [45]	–	–	RYGB	GERD	–	–	–	–	–	–	–	–	–	–	–	–
Morales 2010 [46]	–	–	NA	GERD	–	–	–	Yes	–	–	Heartburn, regurgitation chest pain	–	–	–	–	–

Table 4 (continued)

Authors	Upper endoscopy at primary surgery	Hiatal hernia repair at primary surgery	Type of revisional surgery	Reasons of revision/conversion	Upper endoscopy at revision	GERD	Hiatal hernia	Dysphagia	Bile reflux	Anatomical stricture/sleeve stenosis	Clinical Presentation	Upper endoscopy	Esophageal manometry	CT	Perioperative complications (up to 30 days)	Outcome with resolution of GERD
Musella 2017 [47]	GERD	No	NA	Persistent GERD	–	–	–	–	–	–	–	–	–	–	–	–
Nedelcu 2015 [48]	GERD	–	Re-LSG	GERD	Yes	–	–	–	–	–	–	–	–	–	–	–
Nimeri 2017 [49]	–	No	RYGB	Severe bile reflux gastritis	Yes	Yes, severe bile reflux gastritis	–	Yes	Yes	No	Epigastric pain, vomiting, failure to thrive, anasarca	Yes	Yes	No	2 years after revision	–
Parikh 2008 [50]	–	No	Re-sleeve + HH repair	Severe GERD	–	–	–	No	Yes	–	Epigastric pain, severe reflux, weight regain	No	Yes	No	6 months after revision	–
Parmar 2017 [51]	–	No	RYGB	GERD	–	–	–	–	–	–	Reflux symptoms, 7 patients had hiatal hernia	yes (4 erosive esophagitis)	–	No	–	Conservative management for 2 patients
Piazza 2015 [52]	–	–	MGB	GERD	–	–	–	–	–	–	–	–	–	–	–	–
Poghosyan 2016 [53]	–	–	RYGB	–	–	–	–	–	–	–	–	–	–	–	–	–
Pok 2016 [54]	–	–	RYGB	–	–	–	–	–	–	–	–	–	–	–	–	–
Quezeda 2016 [55]	–	–	RYGB (AL 150, BPL 20–30)	GERD, weight regain, stenosis	GERD, Barrett, HH	–	–	–	–	–	Heartburn, regurgitation (Monteral criteria)	–	–	–	–	Resolution 63%, 31% improvement, 6% stable
Rayman 2020 [56]	–	–	OAGB,RYGB	Revision after sleeve (weight regain)	–	–	–	–	–	–	–	–	–	–	–	Pre revision GERD 69 of 263 (RYGB 41, OAGB 28, post revision GERD 34, RYGB 9, OAGB 25)
Scozzari 2010 [57]	–	–	RYGB	Severe GERD	–	–	–	–	–	–	–	–	–	–	–	–

Table 4 (continued)

Authors	Upper endos-copy at primary surgery	Hiatal hernia repair at primary surgery	Type of revi-sional surgery	Reasons of revision/conversion	Upper endoscopy at revision	GERD	Hiatal hernia	Dys-phagia	Bile reflux	Ana-tomical stricture/sleeve stenosis	Clinical Presentation	Upper endos-copy	Esopha-geal manom-etry	CT	Perioperative complica-tions (up to 30 days)	Outcome with resolution of GERD
Seki 2015 [58]	–	–	Laparoscopic seromyotomy	severe GERD	–	–	–	–	–	–	–	–	–	–	–	–
Ser 2019 [59]	–	–	RYGB, HH	GERD, esophagitis	–	–	–	–	–	–	–	–	–	–	–	–
Soong 2019 [60]	–	–	HH repair and gastropexy	Intractable GERD	GERD	–	–	–	–	–	–	–	–	–	–	Endoscopic improve-ment 28 vs 16 ($p < 0.001$)
Srikanth 2011 [61]	–	–	RYGB	weight regain, GERD + band problems	–	–	–	–	–	–	–	–	–	–	–	–
Yilmaz 2017 [62]	–	–	RYGB	GERD + poor weight loss, weight regain	–	–	–	–	–	–	–	–	–	–	–	5 patients asympto-matic, one positive De Meester Score

interval between surgery and GERD, and follow-up are presented in Table 2.

Reasons for reoperation following primary bariatric surgery included mainly intractable GERD ($n = 655$, 71.58%), GERD + weight regain/weight loss failure ($n = 147$, 16.06%) and biliary reflux ($n = 57$, 6.22%) and are presented in Table 3.

Table 4 includes the type of revisional bariatric surgery and the clinical characteristics of GERD of the studies included in the meta-analysis.

Revisional bariatric surgery for GERD included seven different procedures including conversion in Roux-en-Y gastric bypass (RYGB) ($n = 32$ studies, $n = 310$), conversion in RYGB with simultaneous hiatal hernia repair ($n = 7$ studies, $n = 80$), hiatal hernia repair with gastropexy ($n = 2$), Braun Anastomosis ($n = 2$), Re-SG ($n = 2$), OAGB ($n = 2$), and seromyotomy $n = 1$.

In four studies, the secondary procedure was not named [41, 42, 46, 47]. Conversion in RYGB was the most performed RBS in this systematic review ($n = 390$ of 533 patients, 73.2%) (Table 4).

Pooled estimation of a meta-analysis of studies reported a GERD of 7%, i.e., 7 out of every 100 surgeries resulted in GERD following primary surgery, needing revisional bariatric surgery (Fig. 2), in which 99% of them experienced remission following secondary surgery as shown in Fig. 3.

It should be mentioned that the study by Bashah et al. [22] was deleted from the forest plot which is why we just included secondary red-surgeries not tertiary.

Discussion

Revisional bariatric surgery (RBS) is rising worldwide because of the considerable rate of weight loss failure and long-term complications following BMS [63]. Central abdominal obesity is associated with increased risk of erosive esophagitis [64] and is the most important risk factor associated with Barrett's esophagus [65]. Although BMS lead to remission of GERD [66], it can lead to de novo GERD or aggravate existing GERD [67]. GERD is one of the most discussed long-term complications after SG, since the recognized sequelae of GERD include Barrett's esophagus and esophageal adenocarcinoma. However, strong evidence about the progression of GERD to esophageal cancer after bariatric surgery is missing. Therefore, the aim of this systematic review and metanalysis was to analyze indications and results of revisional bariatric surgery due to GERD.

Analyzing a total of 722 studies and examining 17.437 patients, we included a total of 48 studies with 915 patients who underwent RBS due to GERD.

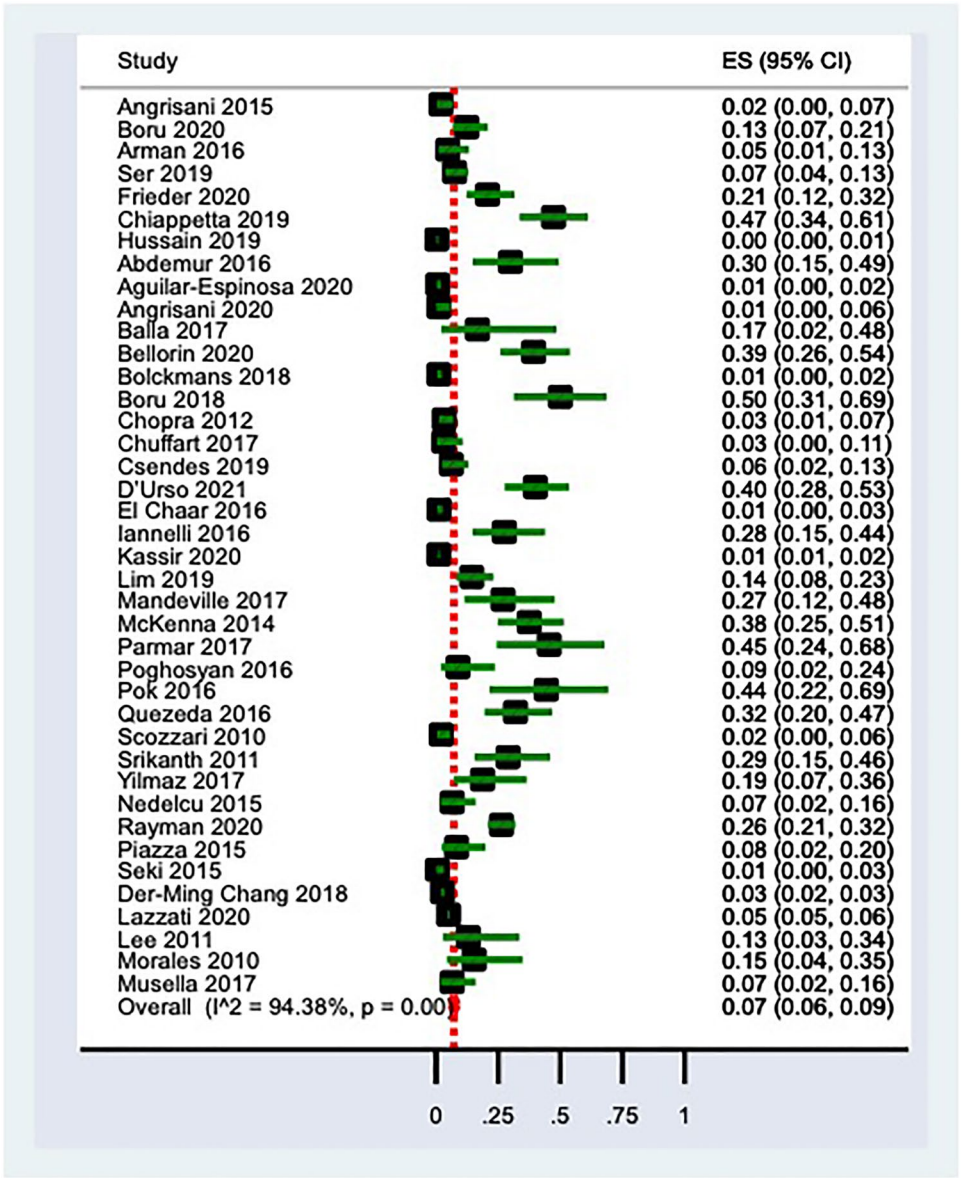

Fig. 2 Percent of GERD before secondary surgery as a forest plot

Interestingly, intractable GERD was with 72% the most important cause for RBS and was associated with weight loss failure in only 16% of the patients. These numbers underline that the presence of GERD is rarely associated with weight loss failure and that the importance of postoperative endoscopic surveillance and treatment standards regarding the long-term complication of GERD are needed [68].

Importantly, SG was the most reported primary bariatric procedure, which needed RBS due to GERD (83.5%). This is important to recognize, since SG is the most performed BMS worldwide [69], and with rising numbers, we must expect more RBS due to GERD in the future. Furthermore, OAGB was the second most reported procedure, which needed RBS due to GERD (6.8%). The discussion regarding bile reflux after OAGB is still up to date and no evidence exists regarding the incidence and risk of Barrett's esophagus and esophageal adenocarcinoma in the long term. Actually, reported data for conversion of OAGB for GERD is low, but since SG has more long-term data published, we should be aware in the future regarding RBS for GERD after OAGB.

The long-term complication of GERD after SG is a well-discussed problem and clinical implications have

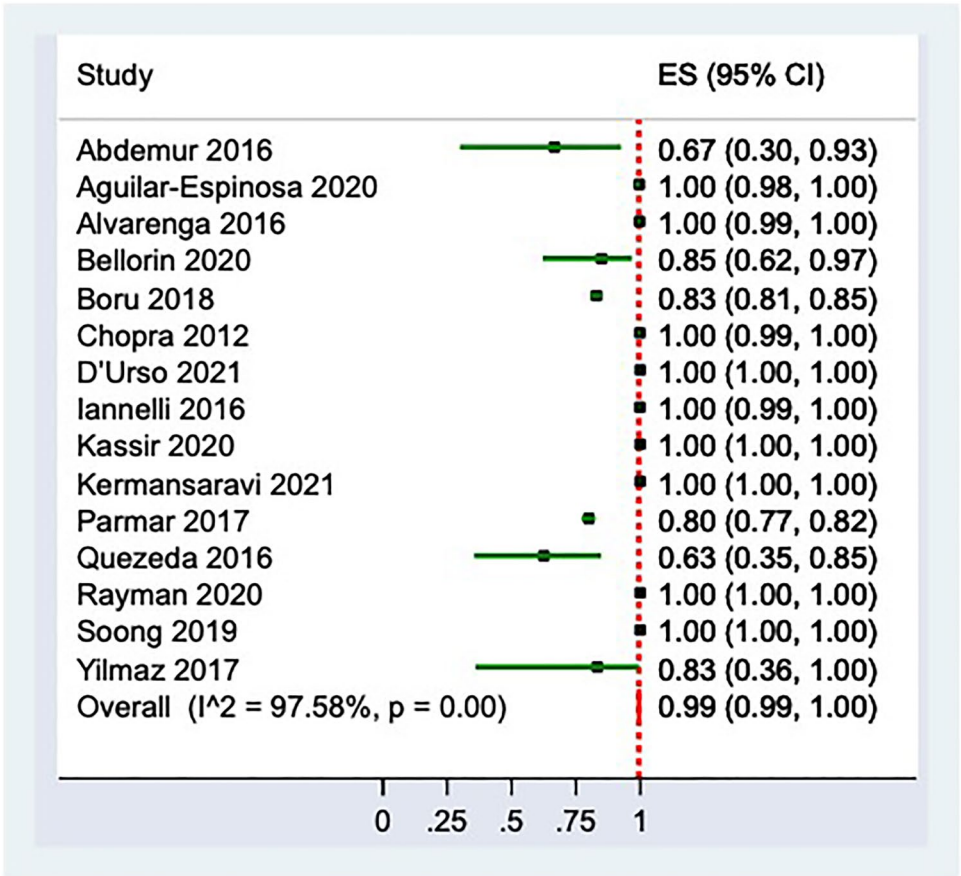

Fig. 3 Percent of remission following secondary surgery as a forest plot

just been adapted to the current clinical practice. Expert Panel Consensus Statement regarding SG [70] concluded that Barrett's esophagus is an absolute contraindication for SG (81% of consensus), but no consensus was found regarding the fact that GERD is a relative contraindication for SG (57% of consensus). Most surgeons agree that in patients with GERD, proton pump inhibitors should be the first line of treatment (85% of consensus).

We still cannot predict the role of GERD and bile reflux after OAGB in the long term. The first Consensus Statement of OAGB had expert disagreement regarding that OAGB is not recommended for patients with Barrett's esophagus (66.34%) and that it is an acceptable surgical option for patients with severe GERD requiring daily medication (69.31%). The consensus agreed that patients developing symptomatic GERD unresponsive to maximal medical therapy after OAGB can be offered surgical correction in the form of a conversion to RYGB (91.09% agree) [71]. Therefore, it seems, that experts are more convinced about the risk of GERD in SG than in OAGB.

A recent prospective study published by Genco et al. analyzing the four most performed obesity and metabolic procedures GB, SG, OAGB, and RYGB showed that GERD complications are of variable severity. The overall prevalence of erosive esophagitis was greater in the SG group (74.7%) than in the GB (42.1%), RYGB (22%), and OAGB (22.9%) groups ($P < 0.0001$). Barrett's esophagus was found only in patients who had SG (16.8%). Biliary-like gastric stagnation was found in a greater proportion of SG and OAGB patients (79.7 and 69.4%, respectively) than in other treatment groups ($P < 0.0001$). The prevalence of biliary-type reflux into the esophagus was higher in patients who underwent SG (74.7%), compared with other treatment groups (67). These findings underline the results of this systematic review, which show that the most performed RBS for GERD is SG in the current published literature.

Pooled estimation of a meta-analysis of studies reported a GERD of 7%, i.e., 7 out of every 100 surgeries resulted in GERD following primary surgery. Since a systematic review estimated the prevalence of GERD in the USA at 18.1–27.8% [72], it should be declared that patients after primary bariatric surgery have a lower incidence of GERD regarding the overall population. Furthermore, pooled estimation of a meta-analysis of the

studies reported a remission of 99%, i.e., 99 out of every 100 surgeries experience GERD remission following secondary surgery. These data might be important, since it shows that RBS regardless of the type of reflux (acid or bile reflux) is effective and after a second bariatric procedure the long-term complication GERD becomes a rare long-term complication. This is important for clinical practice and the data reassure surgeons in performing RBS in GERD after primary BMS.

Furthermore, it has to be underlined that only three of 48 studies performed esophageal manometry prior to RBS. This fact might claim the critical question, if in clinical symptoms and confirmed endoscopic esophagitis further diagnostic studies are necessary, since 99 out of every 100 surgeries experience GERD remission following secondary surgery.

The interval between primary and RBS due to GERD was reported to be 31.23 months. We are talking indeed of a long-term complication and these data underline the importance of long-term follow-up even after the second year of surgery.

Although current literature report seven different surgical treatment options, conversion in RYGB was the most performed RBS in this systematic review ($n = 390$ of 533 patients, 73.2%). This underlines the fact that nowadays RYGB is the most performed RBS in treating GERD after primary BMS.

The weaknesses and limitations of this systematic review and meta-analysis include mainly the problem of the mixed published data in the literature. In the analyzed studies, GERD was often included with other long-term complications after a specialized surgical procedure, or different primary bariatric procedures were mixed in the studies. Furthermore, the diagnostic tools regarding GERD are often mixed and pH-metry and manometry are rarely performed in the studies. Fundamentally, prospective trials may be needed to identify risk factors for developing GERD after primary BMS and randomized control trials regarding the treatment of GERD after primary BMS should be performed in the future.

Nevertheless, this is the first systematic review and meta-analysis which addresses the long-term complication of GERD as an indication for RBS with 915 patients included.

Conclusion

After primary BMS, pooled estimation of a meta-analysis of studies reported a GERD of 7%. SG was with 83.5% the most reported primary bariatric metabolic procedure, which needed RBS due to GERD, followed by OAGB with 6.8%. Pooled estimation of a meta-analysis of the studies reported a GERD remission of 99% following secondary surgery. Although current literature report different surgical treatment options, conversion in RYGB (73.2%) was the most performed RBS.

This study underlines the importance of GERD in the long-term, especially after SG, but on the other hand demonstrates the evidence that RYGB is an efficient surgical treatment option for this long-term complication.

Author Contribution All authors performed substantial contributions to conception and design of the article and to acquisition, analysis, and interpretation of data. All authors reviewed the manuscript for important intellectual content and approved the final version for publication. All authors agree to be accountable for all aspects of the work in ensuring that questions related to the accuracy or integrity of any part of the work are appropriately investigated and resolved.

Declarations

Ethics Approval All procedures performed in studies involving human participants were in accordance with the ethical standards of the institutional and/or national research committee and with the 1964 Helsinki declaration and its later amendments or comparable ethical standards.

Informed Consent Informed consent does not apply.

Conflict of Interest The authors declare no competing interests.

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