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Effectiveness of laparoscopic Roux-en-Y gastric bypass and sleeve gastrectomy for morbid obesity in achieving weight loss outcomes

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A R T I C L E I N F O

Keywords:
Laparoscopic sleeve gastrectomy
Laparoscopic Roux-en Y gastric bypass
Morbid obesity
Percentage total weight loss

A B S T R A C T

Objective: Laparoscopic Roux-en-Y gastric bypass (LRYGB) and laparoscopic sleeve gastrectomy (LSG) are commonly performed weight loss procedures worldwide. Unfortunately, few studies have compared percentage total weight loss (%TWL) following these procedures. This research compared short-term, mid-term and long-term %TWL by LRYGB and LSG.

Methods: Selected databases were searched for original articles that compared %TWL by LSG and LRYGB. Review manager 5.3 was used for data analysis. Effect summary was presented by forest plot.

Results: A significantly better %TWL in 5 years was shown by LRYGB than LSG; pooled mean difference (MD) 1.87 (95% CI 0.27–3.48, z statistics = 2.28, $p < 0.05$). Subgroup analysis showed better %TWL by LRYGB than LSG at 24 months pooled MD 6.47 (95% CI 1.22–11.72, z statistics = 2.42, $p < 0.05$), however, better %TWL by LSG was noted after 36 months (pooled MD -0.23; 95% CI -0.39–0.06, z statistics = 2.65, $p < 0.05$). Finally, significantly better %TWL was noted for LRYGB at 60 months.

Conclusion: This study shows %TWL of 70.4% by LRYGB and 59.8% following LSG in at least half of patients from selected cohort. A significantly greater %TWL by LRYGB in short and long term, while higher %TWL by LSG in mid-term is reported.

1. Introduction

According to the World Health Organization (WHO) report in 2016, there were an estimated 1.9 billion overweight adults over the age of 18 and, out of those, 650 million were obese [1]. The global proportion of overweight/obese adults has increased from 28.8% to 36.9% in males, and 29.8%–38% in females between 1980 and 2013. According to the National Center for Health Statistics USA, in 2015–16, the prevalence of obesity among U.S. adults and youth was 39.8% and 18.5%, respectively [2]. In 2017, Cregg and Shaw collected data from 195 countries about model trends in overweight and obesity and have shown that prevalence of obesity has almost doubled since 1980 and has been reported as 5% in children and 12% in adults.

A wealth of strategies have been employed for obesity management that includes patient counselling, psychological advice, lifestyle and dietary modifications and weight loss surgery. Of these, bariatric surgery offers the most effective and sustainable weight loss in obese individuals [4]. The American Society for Metabolic and Bariatric Surgery has reported an estimated 179,000 metabolic procedures in 2015 and 196,000 in 2016 in United States [5]. Traditionally, both restrictive (reduced gastric volume) and malabsorptive (reduced absorption of ingested nutrients) weight loss procedures have been used [6]. However, apart from obvious restrictive or malabsorptive functions, a number of other regulatory mechanisms lead to alterations in the physiology of energy balance, secretions, and neurotransmitters influence satiety, energy expenditure, and glucose homeostatis following weight loss surgery [7]. So far, laparoscopic Roux-en-Y gastric bypass (LRYGB) and laparoscopic sleeve gastrectomy (LSG) are the two most popular bariatric surgery procedures performed worldwide [5].

In LRYGB, a malabsorptive weight loss procedure, the proximal jejunum is divided 5–10 cm distal to the ligament of Treitz with a 45-mm linear cutter [8]. For patients with body mass index (BMI) ≤ 50, a 100-cm limb is selected; while a 150-cm limb is selected for patients with BMI ≥ 50. In the next step, a side-to-side jejunojejunostomy is done with a 45-mm linear cutter, 2.5-mm stapler and the enterotomy is closed with interrupted sutures. A 20 mL gastric pouch is created using 35-mm linear cutter, 3.5-mm stapler (ENDOPATH Endoscopic Linear Cutter; Ethicon Endo-Surgery Inc). The Roux limb is brought up through retrocolic route and a standard 2-layer hand-sewn gastrojejunostomy anastomosis is performed around an intraluminal 32 F

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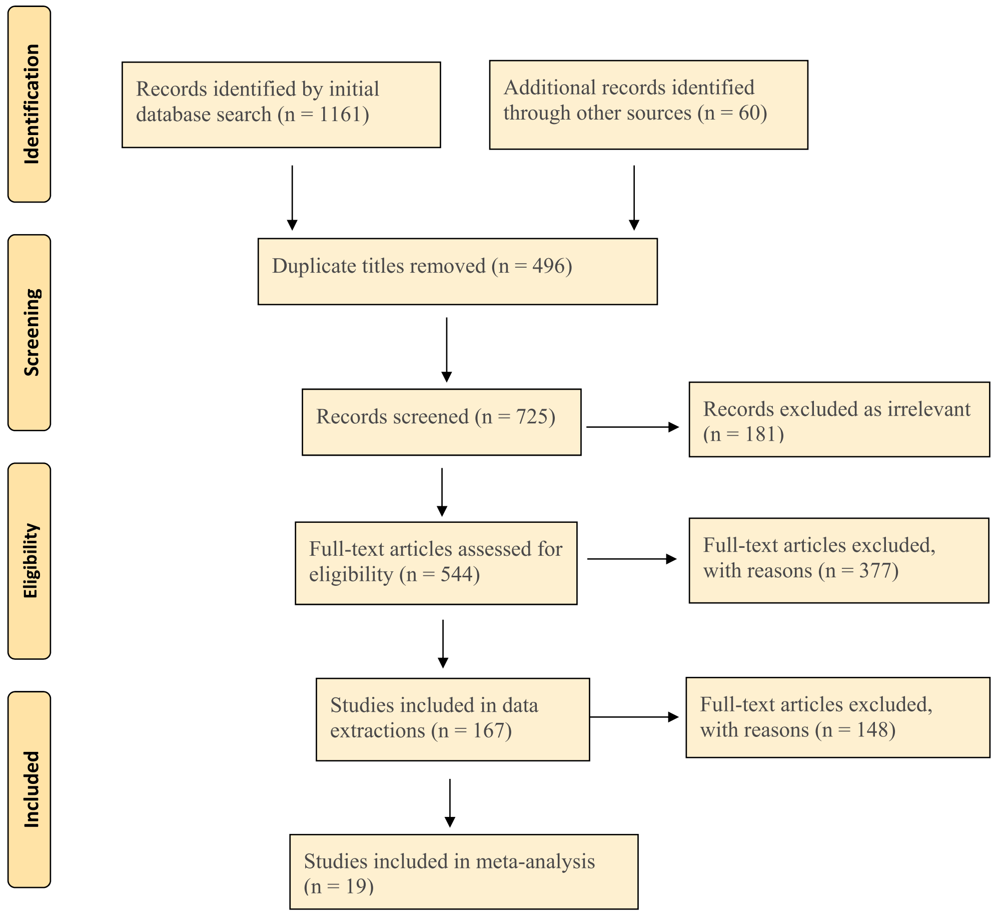

Fig. 1. Flow diagram showing systematic algorithm for selection of studies in this meta-analysis.

tube. LSG, a restrictive bariatric procedure, involves resection of a greater part of body and fundus of the stomach alongside the greater curvature. LSG is the most popular stand-alone bariatric procedure in high-risk patients [9]. Outright benefits of LSG include the maintenance of anatomical continuity of gastro-intestinal tract, low rate of complications, short learning curve for the surgical trainees and no risk of malabsorption such as dumping syndrome and marginal ulcers [10]. Nevertheless, the value of surgical training for enhancing psychomotor skills in accredited training centers has shown significantly improved outcomes [11,12].

Comparable outcomes to LRYGB and LSG in terms of %TWL, treatment of co-morbidities and quality of life have been reported in several studies [13–15]. The preferred means of determining weight loss by bariatric surgery is %TWL rather than original body weight [16]. Two recent meta-analyses, comparing %EWL by both surgical techniques, have shown better %TWL by LRYGB [17,18]. However, these studies primarily included nonrandomized clinical trials without controls that might have provided more robust comparative analysis of both surgical procedures. On the other hand, in a clinical trial by Peterli et al., in 2018, the researchers did not find significant difference in %TWL between LRYGB and LSG at 5 years after surgery [19]. Though the study reported less %TWL by LSG than LRYGB at 5 years, the difference was not statistically significant. A study compared the effectiveness of LSG and LRYGB in terms of %TWL in midterm and has reported superiority of LSG over LRYGB [20]. In contrast, two long-term studies have shown significantly more %TWL by LRYGB than with LSG [21,22].

Though a wealth of polished reports of clinical trials have attempted to determine %TWL achieved by LSG and LRYGB separately, however, available data does not indicate substantial superiority of either surgical procedure. This systematic review and meta-analysis was conducted to determine difference in %TWL achieved by LRYGB and LSG in morbidly obese patients as end point outcome.

2. Methods

2.1. Search design

This systematic review and meta-analysis was conducted in line with PRISMA (Preferred Reporting Items for Systematic Reviews and Meta-Analyses) and AMSTAR (Assessing the methodological quality of systematic reviews) Guidelines [23] in January 2019 to explore using Medical Subject Headings (MeSH) Morbid obesity; Excess weight loss; Bariatric Surgery; Weight loss surgery; Body mass index. The databases searched included PubMed-Medline, Wiley online library, Cochrane library, Taylor and Francis Online, CINAHL, Springer link, Proquest, ISI Web of knowledge, ScienceDirect, EJS, EBSCO, Blackwell, Emerald and ABI Inform. Full-text English original clinical studies, published during 2015–2018 that compared %TWL by LSG and LRYGB for 1–5 years after surgery were included in this search. Editorials, personal opinions, commentaries, review article brief communications were excluded. In addition, studies with unobtainable outcomes of interest as mean ± standard deviation (SD) (for continuous outcome) or number or percentage (for dichotomous outcome) or an average follow-up of one year and studies that investigated on patients with a body BMI < 27 kg/m2 or aged < 18 or > 65 years old were excluded. Finally, research conducted on combined data of revision or conversion surgeries was not included in this study.

2.2. Data extraction and synthesis

During initial search, 1161 articles were retrieved. Another 60 articles were found during second round of search. Analysis of retrieved titles showed 496 duplicate titles, which were removed from later part of literature review. During further review, a total of 558 articles were excluded as the content and research domains did not match inclusion criteria. As many as 167 studies were found relevant. However, during full text analysis of these relevant studies, 148 were furtherer excluded due to inappropriate data and inconsistent reports. Finally, 19 relevant studies met the inclusion criteria, which were selected for this meta-analysis. (Fig. 1).

The characteristics of data extracted from the selected studies included author/s, publication year, country of study, retrospective or prospective, sample size, and follow-up. Furthermore, patients' average age and preoperative BMI, gender and post-operative outcomes in terms of %TWL loss were recorded for further analysis.

2.3. Quality assessment

Two independent researchers analysed the retrieved data for suitability and representativeness of studies. Primarily, patients' characteristics, comparability of pre and post-operative results, and outcome assessment were recorded. Any conflict of interest was resolved by discussions and by reaching a general consensus.

2.4. Analysis of quantitative data

The selected studies in this meta-analysis were analyzed through Review Manger 5.3 software developed by Cochrane Library [24]. Meta-analysis was graphically depicted by forest plot that presents consistency and reliability of results of selected studies. In this plot, the effect size of each study is computed as an outcome and pooled effect summary is also calculated to observe heterogeneity across studies. Q test shows heterogeneity in selected studies using null hypothesis that *all studies are identical*. The I squared (I^2) statistical analysis was done to ensure quantity of heterogeneity in percentage terms [25]. In case of low heterogeneity ($p > 0.10$, $I^2 < 50\%$), a fixed effects model is recommended, however, a random effects model is most commonly used in the event of high heterogeneity ($p < 0.10$ or $I^2 > 50\%$). The Tau squared (Tau^2) was used to estimate study variance in random effects model. In this research, publication bias was determined by examination of the funnel plot obtained from all selected studies. The level of significance in this study is 5% ($p < 0.05$).

2.5. Empirical results

This systematic review and meta-analysis presents a quantitative analysis of 4742 patients from 19 studies. Table 1 shows characteristics of selected studies: study, years of publication, study type, sample size, average BMI and number of patients at the time of surgery for both LSG and LRYGB.

Fig. 2 compares average BMI of patients in LSG and LRYGB groups at the time of surgery, which shows similar average BMI in both groups.

The final output of this meta-analysis is shown by forest plot of 19 selected studies with an obtainable mean ± SD for %TWL by LRYGB and LSG after a follow up of 1–5 years with significant difference between two surgical techniques with a pooled mean difference of 1.87 (95% CI 0.27–3.48, z statistics = 2.28, $p < 0.05$) as outlined in Fig. 3.

Overall, a %EWL of 70.4% by LRYGB and %EWL of 59.8% following LSG in at least half of the patients from the selected cohort is reported. The Conchre Q ($Chi^2 = 154.43$) test was significant at 5% ($p < 0.05$), thus rejecting the null hypothesis that all studies were identical. On the basis of considerable heterogeneity (I^2 88%), a random effect model was deemed appropriate for this study. The findings showed that LRYGB was associated with more significant %EWL than reported by LSG. Fig. 4 illustrates comparison of %EWL outcomes between LRYGB and LSG patients.

Visual inspection of the funnel plot did not show any asymmetry of studies regarding differences in %EWL outcomes by LRYGB and LSG (Fig. 5).

Sub group analysis of the %TWL outcome after 0–24, 36, and 60 months follow up are shown in Fig. 6a, b, and 6c, respectively.

Fig. 6a shows a significant difference in %TWL by LRYGB than LSG (pooled mean difference of 6.47 with 95% CI 1.22–11.72, z statistics = 2.42, $p < 0.05$) after 0–24 months follow up. However, the findings are subject to considerable heterogeneity ($I^2 = 93\%$). Fig. 6b reports significantly greater %TWL by LSG than LRYGB in medium term follow up of 36 months as reflected by pooled mean difference of −0.23 (95% CI -0.39–0.06, z statistics = 2.65, $p < 0.05$). But the findings are subject to relatively low heterogeneity ($I^2 = 81\%$) as compared to main findings. Finally, in long run, a significant difference of %TWL between LRYGB and LSG after 60 months follow up was reported (Fig. 6c).

3. Discussion

This systematic review and meta-analysis of 4742 patients reports a significantly better %TWL outcome by LRYGB at 5-year follow up with a pooled mean difference of 1.87 (95% CI 0.27–3.48, z statistics = 2.28, $p < 0.05$). This study reports %TWL of 70.4% by LRYGB and %EWL of 59.8% following LSG in at least half of the patients from this study group. The subgroup analysis of forest plot has shown significantly greater % EWL by LRYGB than LSG; pooled mean difference of 6.47 (95% CI 1.22–11.72, z statistics = 2.42, $p < 0.05$) at 0–24 months follow up and pooled mean difference of −0.23 (95% CI -0.39–0.06, z statistics = 2.65, $p < 0.05$) at 36 months. Finally, significant better %TWL has been reported by LRYGB over LSG during 60 months follow up.

The current systematic review and meta-analysis shows better %TWL outcomes by LRYGB in short and long term, while LSG shows greater %TWL in mid-term. In this study, 11 studies showed %TWL after 2 years follow up and 5 studies reported %TWL after 3 years as shown in Tables 6 and 7 However, no randomized controlled trials were conducted in these studies that could have provided more scientific evidence for primary end-point outcome. The published literature has shown a mix of results in terms of effectiveness of securing %TWL by LSG and LRYGB in short, mid and long term duration In a retrospective, non-randomized clinical trial by Gonzalez-Heredia et al.,. The authors reported better %TWL by LRYGB than LSG for super–super obese patients at 12 and 24 months follow up [26]. Interestingly, there were no significant differences in terms of postoperative complications and duration of hospital stay between LSG and LRYGB. Other studies have also endorsed similar findings at 2 year follow up [27,28]. In the study by Park and Kim, the researchers reported a significantly shorter operating time by LSG than LRYGB (100 min vs 130 min, $p < 0.001$; 1 d vs 2 d, $p = 0.003$), but, interestingly, the rate of perioperative complications was similar. The mean %TWL for LRYGB and LSG was 71.2% and 63.5%, respectively [29]. The study concluded that both LRYGB and LSG were effective surgical remedies for weight loss in mid-term duration.

From a prospective clinical trial on 510 obese patients, Lee at al, have shown similar %TWL results by LSG and LRYGB at 5-year follow up [30]. The authors have inferred that %EWL outcomes by LSG in 5 years were not inferior to LRYGB and have recommended LSG as an ideal bariatric surgery procedure for morbidly obese patient. In the SLEEVEPASS randomized clinical trial by Salminen et al. investigating the long-term end-point outcome at 5 years, the authors compared % EWL by LRYGB and LSG and have shown 49% %TWL after LSG and 57% by LRYGB [31]. Although LRYGB reported greater %TWL at 5 years of follow up, there was no significant difference between the two surgical procedures in terms of pre-specified equivalence margins. The study by Kikkas et al. has shown %EWL of 61.0% ± 24.3% at 5 years by LSG, which is comparable to %TWL of 59.8% by LSG in our meta-analysis [32]. There is a consensus on greater short term safety profile of LSG but gastroesophageal reflux disease and Barrett's esophagus are

Table 1
Characteristics of the selected 19 studies that compared percentage total weight loss by laparoscopic sleeve gastrectomy and Roux-en-Y gastric bypass (4742 patients).

Study	Year	Country	Study Type	Sample Size		Average BMI at Baseline	
				LSG	LRYGB	LSG	LRYGB
Dakour Aridi, Wehbe [39]	2017	Lebanon	Retrospective	400	175	42.3 ± 6.6	45.1 ± 7.5
El Chaar, Hammoud [40]	2015	USA	Retrospective	338	547	44.49 ± 6.28	47.07 ± 7.78
Dogan, Gadiot [41]	2015	Netherlands	Retrospective	245	245	45.8 ± 6.0	47.2 ± 5.8
Lee, Heo [42]	2017	India	Case Control	40	40	43.9 ± 5.5	45.8 ± 4.8
Gonzalezheredia, Sanchezjohnsen [43]	2016	USA	Retrospective	77	12	64.9 ± 4.2	64.2 ± 2.5
Javanainen, Penttila [44]	2018	Finland	Retrospective	215	545	50.3 ± 30	51.8 ± 34
Lee, Pok [45]	2015	Taiwan	Retrospective	515	515	37.5 ± 6.1	37.5 ± 6.0
Murphy, Clarke [46]	2018	New Zealand	Prospective	53	56	41.9 ± 5.9	42.2 ± 6.2
Pekkarinen, Mustonen [47]	2016	Finland	Retrospective	94	163	48.5 ± 8.1	49.5 ± 5.5
Perrone, Bianciardi [48]	2015	Italy	Prospective	162	142	47.4 ± 4.2	46.8 ± 3.6
Salminen, Helmio [49]	2018	Finland	Randomized clinical trail	121	119	45.5 ± 6.2	46.4 ± 5.9
Schneider, Peterli [50]	2016	Switzerland	Prospective	23	19	43.4 ± 5.9	44.4 ± 6.3
Yang, Wang [51]	2015	China	Retrospective	28	27	42.3 ± 6.6	45.1 ± 7.5
Praveenraj, Gomes [52]	2016	India	Retrospective	54	32	43.8 ± 9.7	42.2 ± 6.5
Du, Zhou [53]	2017	China	Retrospective	19	64	32.1 ± 2.8	31.2 ± 3.4
Park and Kim [54]	2015	Korea	Retrospective	104	236	39.1 ± 6.8	37.5 ± 6.0
Gray, Moore [55]	2018	USA	Retrospective	65	69	44.4 ± 6.3	43.6 ± 5.9
Wallenius, Dirinck [56]	2018	Sweden	Retrospective	15	18	36.9 ± 0.7	38.6 ± 0.8
Perrone, Bianciardi [57]	2017	Italy	Retrospective	162	142	47.4 ± 4.2	46.8 ± 3.6

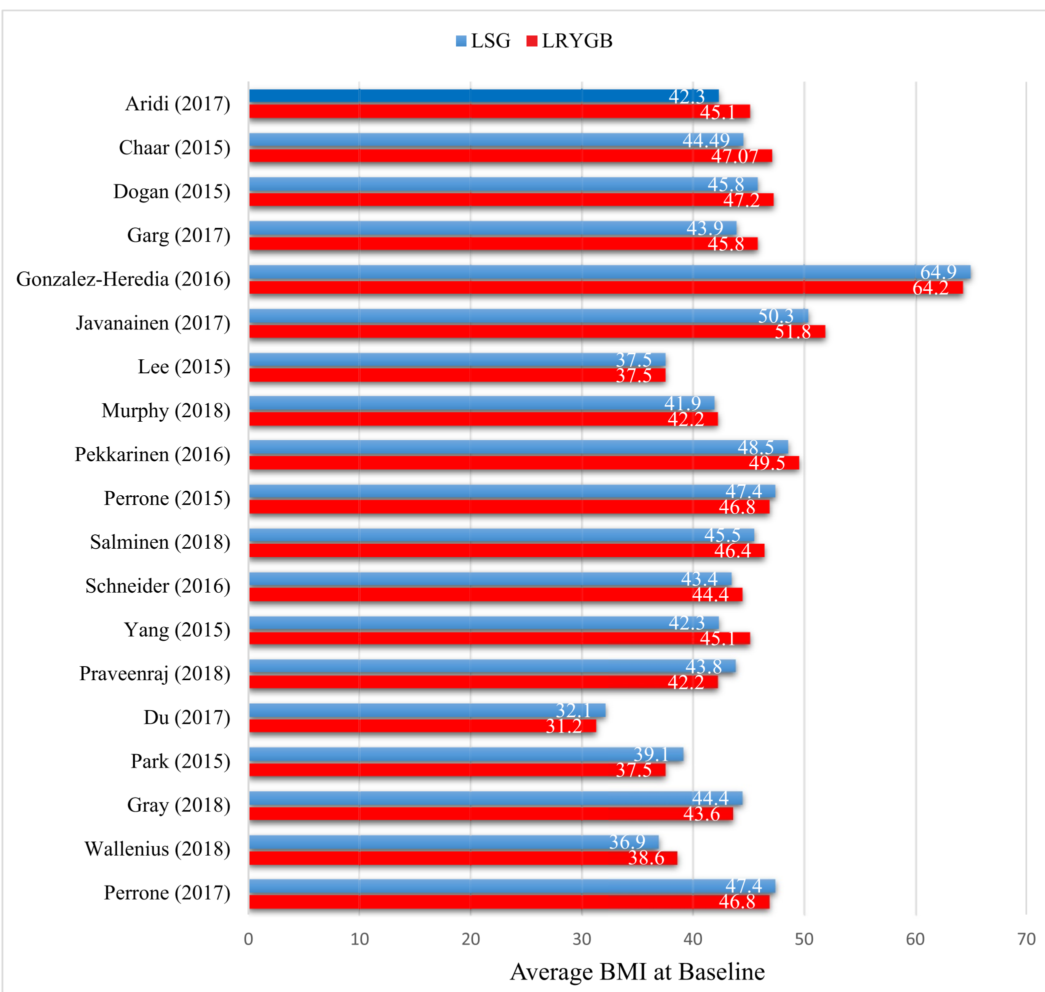

Fig. 2. Average baseline body mass index of patients in LSG and LRYGB groups in this meta-analysis
SG; laparoscopic sleeve gastric bypass LRYGB; laparoscopic Roux-en-Y gastric bypass.

	LRYGB			LSG				Mean Difference
Study or Subgroup	Mean	SD	Total	Mean	SD	Total	Weight	IV, Random, 95% CI
Aridi (2017)	63	21	175	72	31	400	6.0%	-9.00 [-13.35, -4.65]
Chaar (2015)	71.42	35.2	547	58.39	32.6	338	5.8%	13.03 [8.47, 17.59]
Dogan (2015)	65.1	23.2	245	62.5	23.8	245	6.2%	2.60 [-1.56, 6.76]
Du (2017)	60.3	11.1	64	67.9	10.9	19	4.7%	-7.60 [-13.21, -1.99]
Garg (2017)	76.7	20.2	40	67.9	17.9	40	2.7%	8.80 [0.44, 17.16]
Gonzalez-Heredia (2016)	61.6	25.5	12	45.1	18.8	77	1.0%	16.50 [1.47, 31.53]
Gray (2018)	23.9	9.3	69	26.9	9	65	7.7%	-3.00 [-6.10, 0.10]
Javanainen (2017)	50.5	22.7	317	45.5	25.2	143	5.5%	5.00 [0.17, 9.83]
Lee (2015)	69	24.2	218	68.7	30.3	116	4.0%	0.30 [-6.08, 6.68]
Murphy (2018)	84.2	26.2	56	70.2	19.4	53	2.6%	14.00 [5.38, 22.62]
Park (2015)	72.04	27.9	236	65.54	32.48	104	3.4%	6.50 [-0.69, 13.69]
Pekkarinen (2016)	44.7	20.4	163	46.9	20	94	5.1%	-2.20 [-7.31, 2.91]
Perrone (2015)	81.6	21.4	142	78.8	23.5	162	5.2%	2.80 [-2.25, 7.85]
Perrone (2017)	72.34	2.1	142	70.26	2.8	162	10.6%	2.08 [1.53, 2.63]
Praveenraj (2018)	82.76	34.26	32	60.19	17.45	54	1.4%	22.57 [9.82, 35.32]
Salminen (2018)	34.5	6.2	41	36.6	5.2	41	8.6%	-2.10 [-4.58, 0.38]
Schneider (2016)	76.4	22.2	19	64.4	24.2	23	1.2%	12.00 [-2.05, 26.05]
Wallenius (2018)	73	5	18	69.1	4.4	15	7.5%	3.90 [0.69, 7.11]
Yang (2015)	5.7	0.7	27	5.9	0.7	28	10.7%	-0.20 [-0.57, 0.17]
Total (95% CI)			**2563**			**2179**	**100.0%**	**1.87 [0.27, 3.48]**

Heterogeneity: $Tau^2 = 6.24$; $Chi^2 = 154.43$, df = 18 ($P < 0.00001$); $I^2 = 88\%$
Test for overall effect: $Z = 2.28$ ($P = 0.02$)

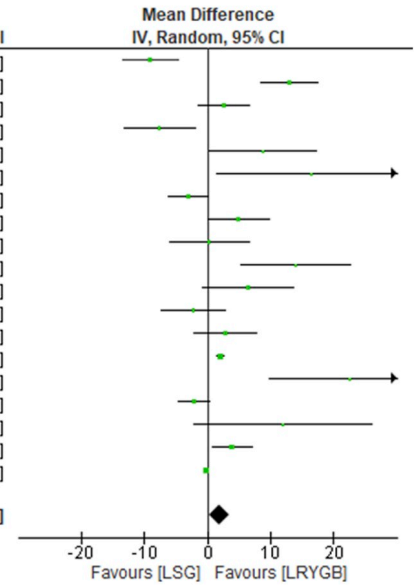

Fig. 3. Forest plot for percentage total weight loss in LRYGB and LSG groups (1–5 years) SG; laparoscopic sleeve gastric bypass LRYGB; laparoscopic Roux-en-Y gastric bypass.

well-known long-term complications of this procedure [33]. This highlights the need for a careful surgical decision-making for the choice of weight loss surgical procedure along with a well-structured post-operative surveillance protocol including endoscopic and physiological evaluation [34,35].

As of today, research has not shown precise regulatory mechanisms that can explain differences in %TWL and resolution of co-morbidities achieved by restrictive and malabsorptive weight loss surgical procedures. However, its known that LSG and LRYGB endanger weight loss and metabolic improvements not only by altering GI anatomy and nutrient flow, but also by some neuro-hormonal mechanisms other than restriction and malabsorption [36]. There are substantial anatomical differences between LRYGB and LSG, which consequently impact upon GI signalling and bodyweight regulation by differently. LSG induces a sustained and more reduction in ghrelin levels than LRYGB as most of the ghrelin-producing cells are located in the gastric fundus [37]. Low ghrelin levels promote satiety and regulates energy homeostasis.

Following anatomic rearrangements in LRYGB, increased nutrient stimulation of intestinal L cells leads to elevated levels of nutrient-stimulated release of peptide YY (PYY) and glucagon-like peptide (GLP-1). In contrast, due to rapid gastric emptying and high exposure of intestinal L cells to the ingested nutrients, LSG leads to increased nutrient-stimulated PYY and GLP-1 levels, but to a lesser degree than LRYGB. Reduced ghrelin and high circulating levels of PYY and GLP-1 are associated with increased satiety and food aversion that ultimately lead to effective weight loss. The circulating levels of another hormone, glucose-dependent insulinotropic polypeptide (GIP), secreted by K-cells in the proximal small intestine, are reduced following LRYGB due to bypassing of the intestine [38]. This analysis provides an insight into the altered regulatory mechanisms particularly the gut hormones that potentially contribute to weight loss following LRYGB and LSG and explain variations in %TWL between two bariatric surgical procedures. However, the exact nature and mechanisms of these neuro-hormonal mechanisms is largely unknown.

4. Conclusion

This systematic review and meta-analysis of 4.742 patients provides a reliable quantitative data that shows significantly better %TWL outcomes by LRYGB in short and long term, while LSG shows higher %TWL in mid-term. In addition, a significantly better %EWL by LRYGB than LSG in long-term is reported. LSG and LRYGB operate through multiple mechanisms, some of which are common to both, others are procedure specific. This study also indicates that bypassing the foregut might

not be the only mechanism responsible for %TWL. Delicate balance between foregut (ghrelin, CCK) and hindgut (GLP-1, PYY) hormones might play vital roles in achieving %TWL following LSG and LRYGB. However, further clinical trials are needed to endorse these findings.

Study limitations

Due to a lack of sufficient number of randomized controlled trials for comparison of LRYGB and LSG for %TWL, this systematic review and meta-analysis showed heterogeneity of results. At the same time, variations in surgical technicalities of the two procedures might have some implications on this research finding.

Ethical approval

Not applicable.

Sources of funding

There is no source of funding.

Author contribution

SYG conceived the research idea, conducted literature review and data analysis, wrote initial and final draft. TS reviewed initial and final draft of the manuscript. Both authors reviewed and approved final draft of manuscript for possible publication in the journal.

Conflicts of interest

No conflict declared.

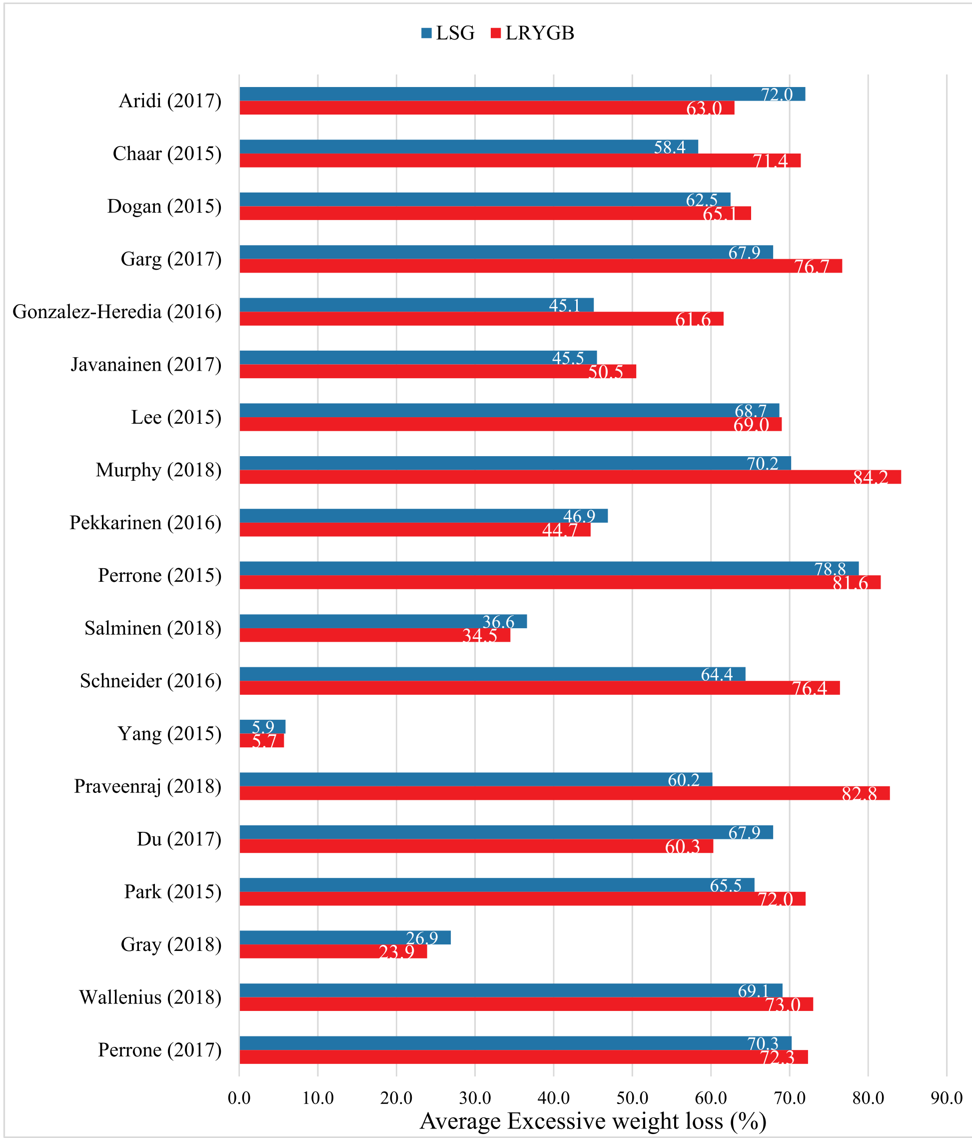

Fig. 4. Comparison of percentage total weight loss outcomes by LSG and LRYGB
SG; laparoscopic sleeve gastric bypass LRYGB; laparoscopic Roux-en-Y gastric bypass.

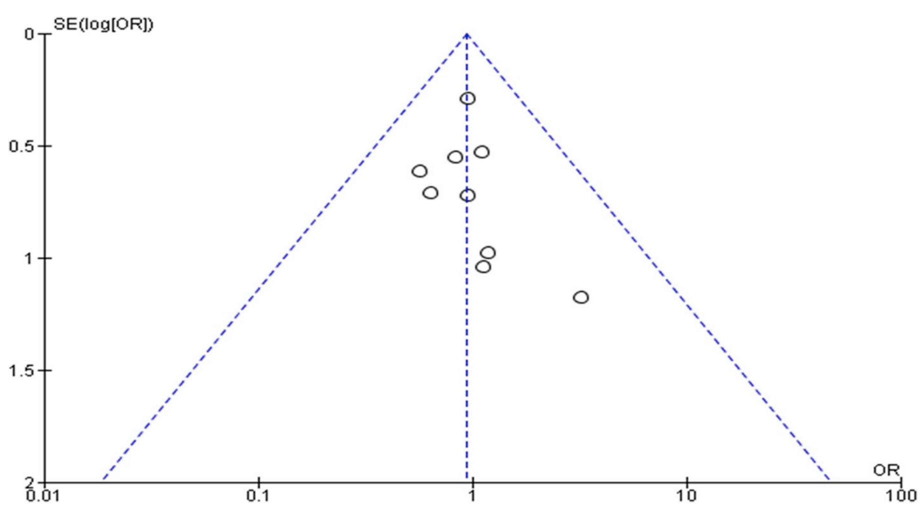

Fig. 5. Funnel plot for percentage total weight loss outcomes by LSG and LRYGB
SG; laparoscopic sleeve gastric bypass LRYGB; laparoscopic Roux-en-Y gastric bypass.

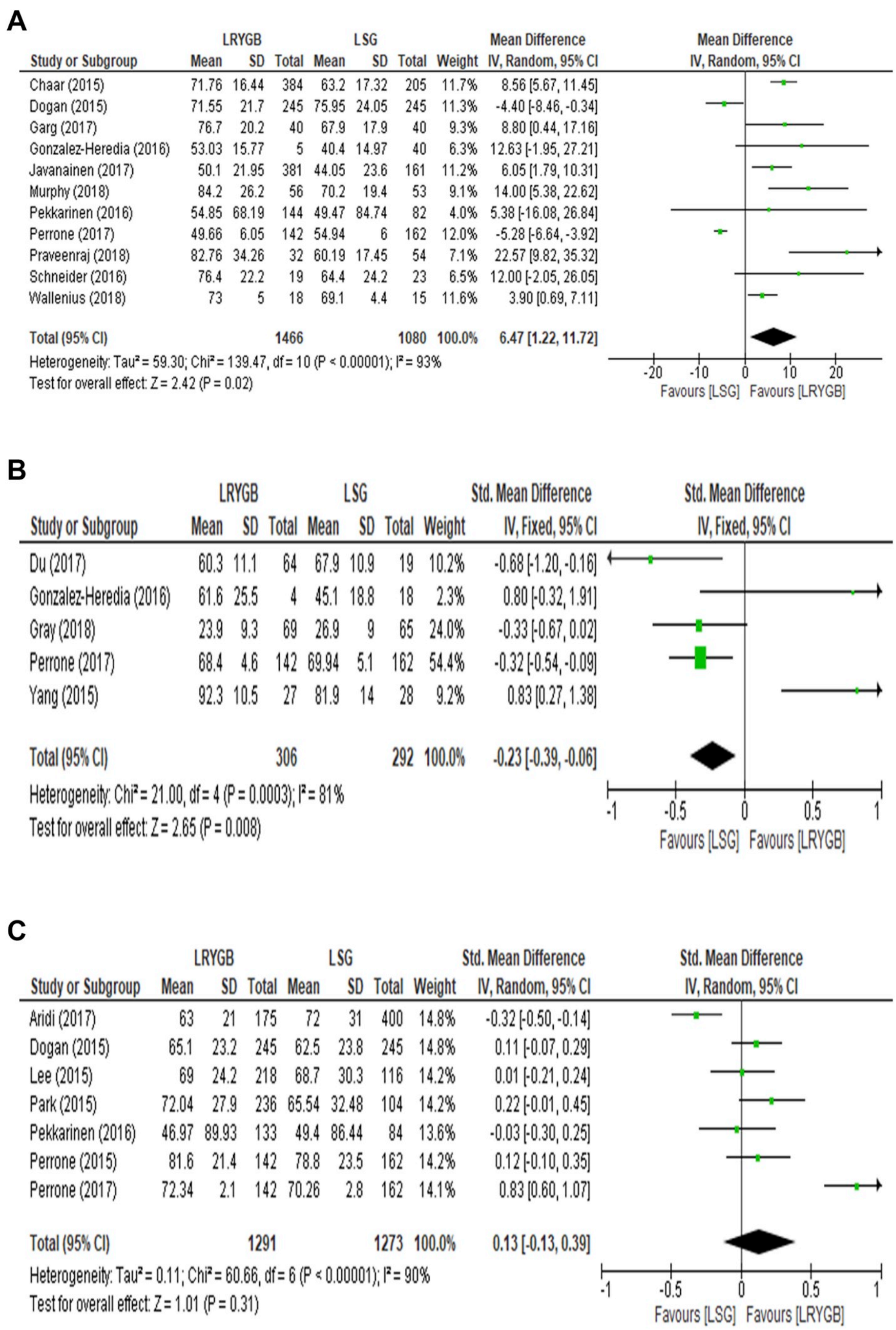

Fig. 6. a: Forest plot of subgroup analysis for percentage excess weight loss achieved by laparoscopic sleeve gastrectomy and Roux-en-Y gastric bypass (Follow up 2 years). SG; laparoscopic sleeve gastric bypass LRYGB; laparoscopic Roux-en-Y gastric bypass. **b:** Forest plot of subgroup analysis for percentage excess weight loss achieved by laparoscopic sleeve gastrectomy and Roux-en-Y gastric bypass (follow up 3 years). SG; laparoscopic sleeve gastric bypass LRYGB; laparoscopic Roux-en-Y gastric bypass. **c:** Forest plot of subgroup analysis for percentage excess weight loss achieved by laparoscopic sleeve gastrectomy and Roux-en-Y gastric bypass (follow up 5 years). SG; laparoscopic sleeve gastric bypass LRYGB; laparoscopic Roux-en-Y gastric bypass.

Trial registry number

1. Name of the registry: Research Registry
2. Unique Identifying number or registration ID: reviewregistry698
3. Hyperlink to the registration (must be publicly accessible): https://www.researchregistry.com/register-now - registryofsystematicreviewsmeta-analyses/registryofsystematicreviewsmeta-analysesdetails/5cfa93b90d27a3000b3ae8d3/

Guarantor

Salman Yousuf Guraya.

Provenance and peer review

Not commissioned, externally peer-reviewed.

Appendix A. Supplementary data

Supplementary data to this article can be found online at https://doi.org/10.1016/j.ijsu.2019.08.010.

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