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ORIGINAL CONTRIBUTIONS

Outcomes After Metabolic Surgery in Asians—a Meta-analysis

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Abstract

Background Obesity and type 2 diabetes mellitus (T2DM) are now increasingly epidemic in Asia. As obesity and T2DM have different disease patterns in Asians compared to Westerners, outcomes after metabolic surgery may differ. The aim of this meta-analysis was to gather the current available evidence on the outcomes after metabolic surgery in Asians.

Methods A literature search was conducted in September 2017. Four outcome measures were examined: (1) % excess weight loss (EWL), (2) post-intervention body mass index (BMI), (3) T2DM resolution **or** improvement, and (4) hypertension resolution.

Results Thirteen publications with a total of 1052 patients were analyzed, of which nine were randomized controlled trials, and four were case-matched studies. All the studies had a minimum follow-up duration of at least 1 year. % EWL was significantly higher in those who have undergone Roux-en-Y gastric bypass (RYGB) (SMD 0.53, 95% CI 0.12 to 0.94) versus sleeve gastrectomy (SG). T2DM resolution/improvement was favorable in those who have undergone RYGB (pooled OR 1.39, 95% CI 0.53 to 3.67) versus SG, although not statistically significant. Hypertension resolution was not significantly different between patients who have undergone SG versus RYGB (pooled OR 0.96, 95% CI 0.44 to 2.11).

Conclusion RYGB results in better weight loss compared to SG in Asians, but the rate of T2DM resolution/improvement and improvement of hypertension appears to be similar. In Asian patients without symptoms of gastro-esophageal reflux disease in whom metabolic surgery is performed mainly for T2DM and metabolic syndrome, SG may be the surgery of choice.

Keywords Metabolic surgery · Bariatric surgery · Roux-en-Y gastric bypass · Sleeve · Gastrectomy · Asian · Diabetes · Hypertension · %EWL · BMI

Introduction

Obesity and type 2 diabetes mellitus (T2DM), once considered diseases of the West, are now increasingly epidemic in Asia. By 2025, Asia will be home to more than 60% of patients with diabetes in the world [1]. Asians with T2DM tend to be young to middle-aged adults, in contrast to Caucasian patients who are likely to be older. For the same body mass index (BMI) in Asians, the prevalence of T2DM is similar or even higher than in Western countries [2]. Asians also and have greater visceral adipose tissue than Caucasians with the same BMI or waist circumference [3]. Higher levels of postprandial glycemia and lower insulin sensitivity in Asians may indicate an underlying genetic susceptibility towards insulin resistance and diabetes [4].

Metabolic surgery is an effective treatment for severe obesity, but the use of metabolic surgery to treat T2DM is pioneered from Asia. It has also shown to result in remarkable improvement in control of T2DM [5], and is superior to medical therapy alone in terms of glycemic control, weight reduction, medication, and quality of life in Western populations [6]. Lee et al. proposed bariatric surgery as a treatment modality for obesity-related T2DM in patients with BMI < 35 kg/m^2 [7]. However, as obesity and T2DM have different disease patterns in Asians compared to Westerners, outcomes after metabolic surgery may differ as well.

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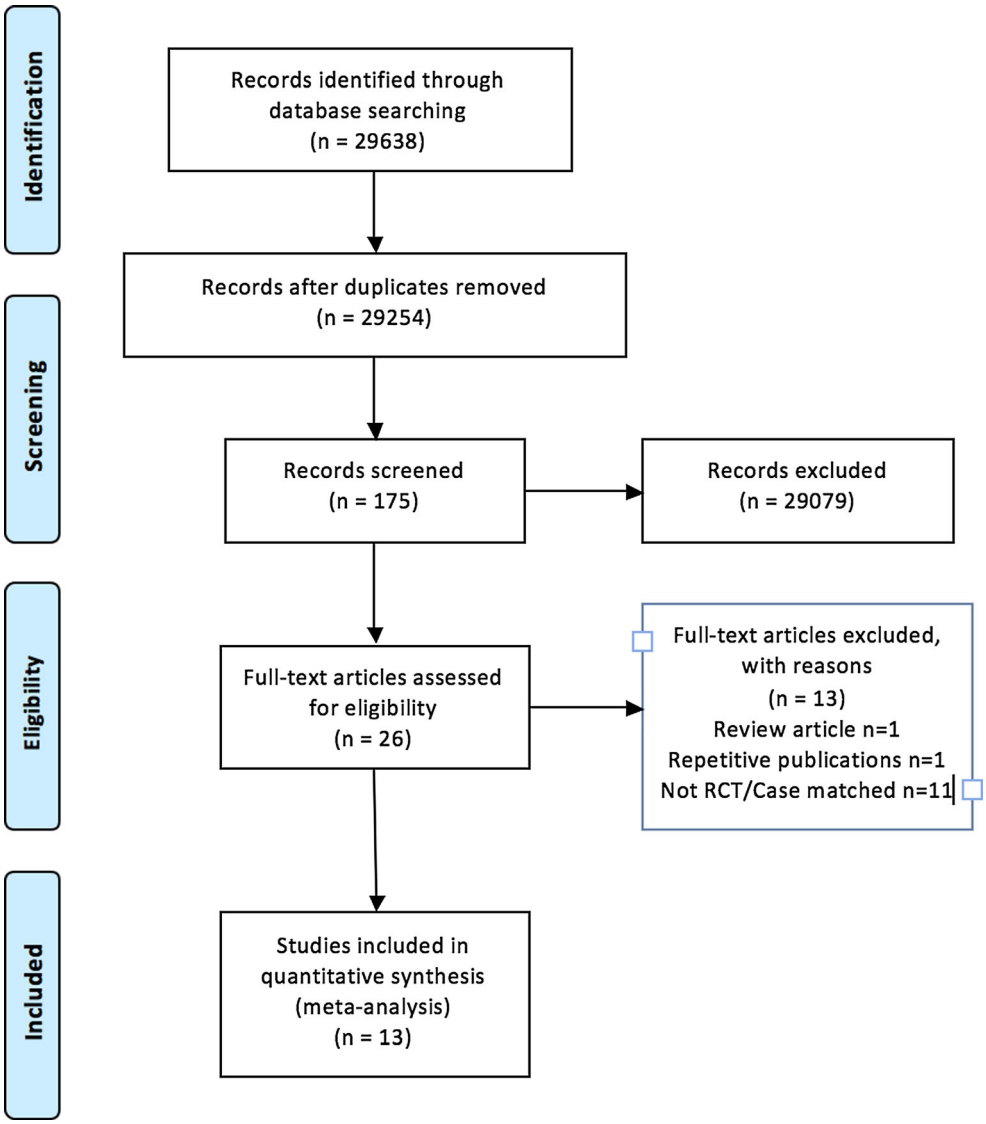

Fig. 1 PRISMA flow diagram on study selection

The aim of this meta-analysis was to gather the current available evidence on the outcomes after metabolic surgery in Asians, and to compare the outcomes of sleeve gastrectomy (SG) versus Roux-en-Y gastric bypass (RYGB).

Methods

Four authors (CY, TY, SA, SP) performed a thorough literature search in September 2017 using Pubmed/MEDLINE,

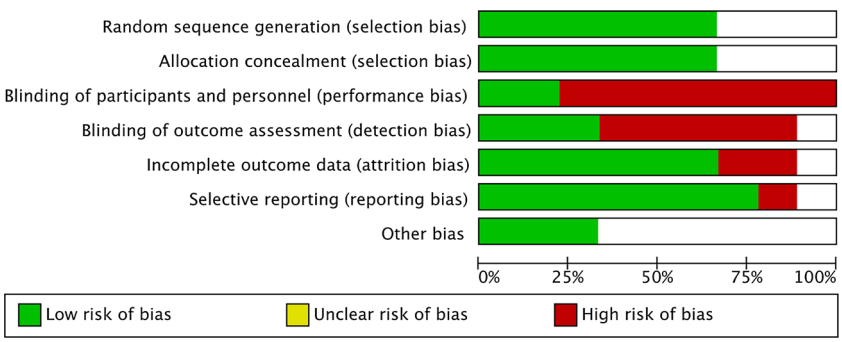

Fig. 2 Cochrane risk of bias assessment for randomized controlled trials

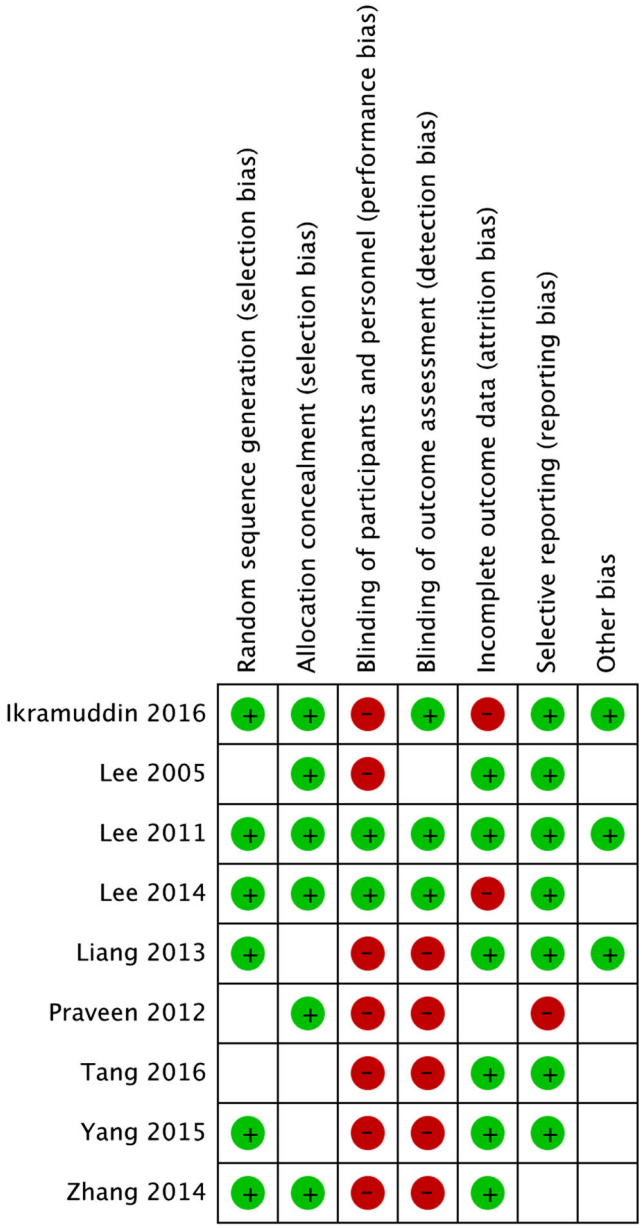

Fig. 3 Cochrane risk of bias assessment for randomized controlled trials

Embase, and the Cochrane Database of Systematic Reviews. The following keywords, alone or in combination, were used in the search: "bariatric surgery," "sleeve gastrectomy," "gastric bypass," "gastric banding," "duodenojejunal bypass," "biliopancreatic diversion," "duodenal switch," "jejunoileal bypass". Only articles reporting original research in English were included. Conference abstracts, review articles, and clinical practice guidelines as well as articles in a language other than English were excluded from this study. The PRISMA guidelines were followed in performing and reporting this meta-analysis [8].

Inclusion Criteria

Articles found using the search terms above were screened by five authors (DY, CY, TY, SA, SP) using the following inclusion criteria: (1) randomized controlled trials or case-matched studies, (2) either the population studied was primarily Asian or the study was conducted in an Asian country. Any disagreement over study selection was resolved by discussion among these five authors.

Using these criteria, 26 articles were obtained in full text and reviewed. Thirteen articles were not included for the reasons shown in Fig. 1.

Assessment of Study Quality

The authors analyzed the 13 articles that met all the above criteria. Bias in randomized controlled trials was assessed using Cochrane risk of bias tool for randomized controlled trials (Figs. 2 and 3), while bias in case-matched studies was assessed using the Newcastle Ottawa Scale as shown in Fig. 4.

Statistical Analysis

Statistical analysis was performed using Stata (version 13.1, College Station, TX: StataCorp LP), significance tests are two-sided at the 5% significance level.

Four outcome measures were examined: (1) % excess weight loss (EWL), (2) post-intervention BMI, (3) T2DM resolution or improvement, and (4) HTN resolution.

Based on the availability of studies, the groups compared were as follows: (1) Roux-en-Y gastric bypass vs. sleeve gastrectomy only; (2) Roux-en-Y gastric bypass vs. non-surgical interventions (where applicable).

For T2DM and HTN resolution, the pooled odds ratio (OR) was estimated using random effects model. An OR > 1 suggests resolution in favor of Roux-en-Y gastric bypass. For %EWL and post-intervention BMI, the weighted mean difference between groups was used to estimate overall mean

Fig. 4 Newcastle Ottawa Scale for assessment of bias for case-matched studies

Studies	Selection	Comparability	Exposure
Huang 2016	★★★★	★★	★★
Du 2016	★★★	★★	★★★
Garg 2017	★★★★	★★	★★★
Hsin 2015	★★★	★	★★

Table 1 Baseline characteristics of included studies

Study	Country	Intervention (*n*)	Total number of patients	Follow-up duration (years)	Study design	Definition of T2DM improvement/resolution	Definition of HTN improvement/resolution
Garg et al. [9]	India	LSG RYGB	80	2	CM	Resolution; FBG < 100 mg/dl in the absence of anti-diabetic medications Improvement; decrease in anti-diabetic medications to maintain normal FBG	Remission: BP < 120/80 mmHg without medication Improvement: BP < 120/80 mmHg with a decrease in dosage or number of anti-hypertensive medications
Ikramuddin et al. [10]	Taiwan and USA	RYGB Medical	119	3	RCT	Resolution; HbA1c < 6.0% at 24 and 36 months with no use of anti-hyperglycemic medications Partial resolution; HbA1c < 6.5% without anti-hyperglycemic medications	NR
Tang et al. [11]	China	LSG RYGB	72	2	RCT	Resolution: HbA1c < 6.0% and FBG < 5.6 mmol/l for at least 1 year without any medication Partial resolution; HbA1c < 6.5% and FBG < 6.9 mmol/l with medications for at least 1 year	NR
Du et al. [12]	China	LSG RYGB	126	3	CM	Resolution: FBG < 5.6 mmol/l and HbA1c < 6% without medications Improvement: Using lower doses of medications, reduction of FBG > 1.39 mmol/l or reduction of HbA1c > 1%	Remission: BP < 120/80 mmHg without medication Improvement: any reduction in hypertension medication
Huang et al. [13]	Taiwan	DJB with LSG RYGB	60	1	CM	Resolution: HbA1c < 6% and FBG < 100 mg/dl in the absence of anti-diabetic medications Partial resolution: HbA1c < 6.5% and FBG 100–125 mg/dl in the absence of anti-diabetic medications	NR
Yang et al. [14]	China	LSG RYGB	55	3	RCT	Resolution: HbA1c < 6.0% without medications Improvement: HbA1c < 6.5%	NR
Hsin et al. [15]	Taiwan	GB LSG RYGB	120	1	CM	NR	NR
Lee et al. [20]	Taiwan	SAGB LSG	60	5	RCT	HbA1c < 6.5% without medications	NR
Zhang et al. [22]	China	LSG RYGB	64	5	RCT	NR	NR
Liang et al. [17]	China	Usual Care Exenatide RYGB	99	1	RCT	NR	NR
Praveen et al. [18]	India	DJB with LSG RYGB	57	1	RCT	Resolution: HbA1c < 7 without the need for medications Improvement: HbA1c < 7 with reduced dose of oral anti-diabetic medications and no insulin	Resolution: no requirement for medications Improvement: reduced requirements of medications
Lee et al. [19]	Taiwan	LSG RYGB	60	1	RCT	Resolution: HbA1c < 6.5% and FBG < 126 mg/dl without the use of anti-diabetic medications	NR
Lee et al. [21]	Taiwan	MGB RYGB	80	2	RCT	NR	NR

CM case-matched, *BP* blood pressure, *DJB* duodenal-jejunal bypass, *FBG* fast blood glucose, *GB* gastric band, *LSG* laparoscopic sleeve gastrectomy, *MGB* mini gastric bypass, *NR* not recorded, *RYGB* Roux-en-Y gastric bypass, *RCT* randomized controlled trial, *SAGB* single anastomosis gastric bypass

Table 2 Study characteristics of included studies

Study	Group	No of patients	Age, year	BMI, kg/m^2 (pre-intervention)	HbA1c, %	Duration of T2DM, year	%EWL	T2DM resolution, no of patients (%)	T2DM improvement/ partial resolution, no of patients (%)	HTN improvement/ resolution, no of patients (%)
Garg et al. [9]	LSG	40	44.8 ± 10.2	45.8 ± 4.8	NR	5	67.9 ± 17.9	21 (77.8%)	6 (22.2%)	15 (37.5%)
	RYGB	40	44.6 ± 10.2	43.9 ± 5.5		7	76.7 ± 20.2	18 (66.7%)	9 (33.3%)	14 (35.0%)
Ikramuddin et al. [10]	Medical	59	49.0 ± 8.0	34.3 ± 3.1	9.6 ± 1.2	9.1 ± 5.7	NR	0	0	NR
	RYGB	60	49.0 ± 9.0	34.9 ± 3.0	9.6 ± 1.0	8.9 ± 6.1		10 (17%)	12 (19%)	
Tang et al. [11]	LSG	34	36.6 ± 8.0	38.4 ± 8.6	7.4 ± 1.8	NR	NR	17 (50.0%)	26 (76.5%)	NR
	RYGB	38	40.4 ± 12.3	37.8 ± 5.6	7.4 ± 1.8			14 (36.8%)	22 (57.9%)	
Du et al. [12]	LSG	63	34.6 ± 10.4	38.9 ± 5.4	NR	NR	65.7	NR	8 (57.1%)	13 (20.6%)
	RYGB	63	33.9 ± 10.1	38.5 ± 5.7			76.5		12 (63.2%)	11 (17.5%)
Huang et al. [13]	DJB with LSG	30	49.8 ± 8.8	28.2 ± 3.6	9.0 ± 1.7	8.0 ± 4.7	NR	11 (36.7%)	5 (16.7%)	4 (13.3%)
	RYGB	30	51.8 ± 9.8	27.8 ± 3.8	9.0 ± 1.8	8.8 ± 7.3		9 (30%)	5 (16.7%)	7 (23.3%)
Yang et al. [14]	LSG	28	40.4 ± 9.4	31.8 ± 3.0	8.5 ± 1.2	4.0 ± 1.7	81.9 ± 14.0	22 (78.6%)	5 (17.9%)	5 (17.9%)
	RYGB	27	41.4 ± 9.3	32.3 ± 2.4	8.9 ± 1.3	4.2 ± 1.9	92.3 ± 10.5	23 (85.2%)	3 (11.1%)	9 (33.3%)
Hsin et al. [15]	GB	40	30.0 ± 8.3	39.2 ± 5.1	NR	NR	61.9 ± 16.8	NR	NR	NR
	LSG	40	30.0 ± 6.4	39.5 ± 3.1			77.1 ± 12.3			
	RYGB	40	30.0 ± 4.8	39.8 ± 3.4			77.1 ± 12.3			
Lee et al. [20]	LSG	30	46.4 ± 8.1	31.0 ± 2.8	9.9 ± 1.8	6.9 ± 5.3	20.1 ± 5.3	2 (6.7%)	9 (30%)	NR
	SAGB	30	44.6 ± 8.6	30.2 ± 2.2	10.0 ± 1.8	5.8 ± 5.7	22.8 ± 5.9	8 (26.7%)	18 (60%)	
Zhang et al. [16]	LSG	32	29.3 ± 9.8	38.5 ± 4.2	NR	NR	63.2 ± 24.5	NR	NR	3 (9.4%)
	RYGB	32	32.2 ± 9.2	39.3 ± 3.8			76.2 ± 21.7			4 (12.5%)
Liang et al. [17]	Usual Care	34	51.8 ± 6.7	30.9 ± 2.0	10.9 ± 1.4	7.2 ± 1.6	NR	0	NR	NR
	Exenatide	34	50.9 ± 5.9	30.3 ± 1.4	10.5 ± 1.5	7.2 ± 1.8		0		
	RYGB	31	50.8 ± 5.4	30.5 ± 3.6	10.5 ± 1.2	7.9 ± 1.6		28 (90%)		
Praveen et al. [18]	DJB with LSG	28	39.5	48.3 ± 3.8	NR	NR	81.94 ± 9.5	16 (66.7%	NR	NR
	RYGB	29	43.5	49.3 ± 3.6			79.98 ± 4.8	13 (81.3%)		
Lee et al. [19]	LSG	30	45.0	30.3 (25.0–34.0	10.0	NR	80.0 ± 4.8	14 (47%)	NR	NR
	RYGB	30					94.4 ± 33.1	28 (93%)		
Lee et al. [21]	MGB	40	20.7 ± 9.1	44.8 ± 8.8	NR	NR	64.4 ± 8.8	NR	NR	NR
	RYGB	40	31.1 ± 9.1	43.8 ± 4.8			94.4 ± 33.1			

DJB duodenal-jejunal bypass, *GB* gastric band, *LSG* laparoscopic sleeve gastrectomy, *MGB* mini gastric bypass, *NR* not recorded, *RYGB* Roux-en-Y gastric bypass, *SAGB* single anastomosis gastric bypass

difference, and random effects model was used. Studies were weighted using the inverse of the variance of the differences in means. Normality within study arms was assumed. Additional analyses were done to examine whether pre-intervention BMI was comparable between groups. Funnel plots were used to examine publication bias. Heterogeneity among included studies was examined using the I^2 statistic.

Results

Overview of Studies

Thirteen publications with a total of 1052 patients were analyzed [9–21], of which nine were randomized controlled trials [10, 11, 14, 16–21], and four were case-matched studies [9, 12, 13, 15] (Tables 1 and 2). All the studies had a minimum follow-up duration of at least 1 year, but only two studies had follow-up of more than 3 years [16, 20]. The definition of T2DM resolution varied among the studies. Of the studies that defined T2DM remission, the most common definition used is the 2009 consensus statement by Buse et al. [23]; whereby complete remission is defined as HbA1c < 6% and fasting glucose < 100 mg/dl (< 5.6 mmol/l) in the absence of medications for at least 1 year, and partial remission is defined as HbA1c < 6.5% and fasting glucose 100–125 mg/dl (5.6–6.9 mmol/l) in the absence of medications for at least 1 year. Definition of remission of hypertension is much more varied among the studies. Garg et al. [9] and Du et al. [12] defined remission of hypertension as blood pressure less than 120/80 mmHg without medication, while Praveen et al. [18] defined hypertension resolution as no requirement for medications. The rest of the studies did not define remission of hypertension. All the studies were conducted in Asia, with the exception of the study by Ikramuddin et al. [10], which is a multicenter trial conducted in both the USA and Taiwan. Funnel plots were performed to examine for possible publication bias for each of the below analyses (Figs. 5, 6, 7, and 8).

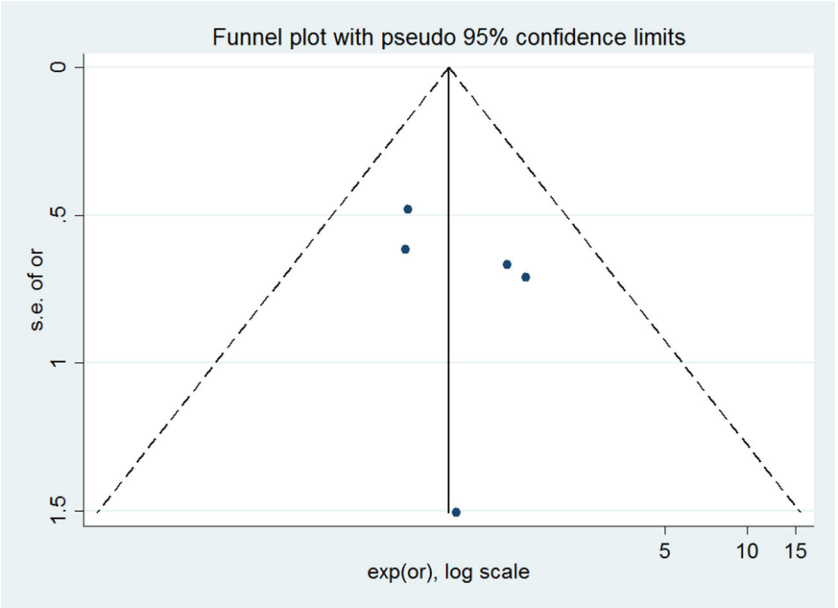

Fig. 5 Funnel plot for resolution of T2DM in patients undergoing Roux-en-Y gastric bypass and sleeve gastrectomy, excluding Lee et al. (2011)

%EWL and BMI

In studies that reported on %EWL after metabolic surgery, the mean %EWL after SG was 65.1 (range 20.1–81.9) [9, 12, 14–16, 19, 20], while the mean %EWL after RYGB was 83.4 (range 76.2–94.4) [9, 12, 14–16, 18, 19, 21]. Six studies [9, 12, 14–16, 19] compared %EWL after SG versus RYGB. The analysis of pooled difference in mean %EWL contained 232 RYGB and 233 SG patients (Fig. 9). % EWL was significantly higher in those who have undergone RYGB (SMD 0.53, 95% CI 0.12 to 0.94) compared to SG. High hereterogenity was observed (I^2 78.9%). Sensitivity analysis was performed by excluding Hsin et al. [15] to achieve a lower heterogeneity of (I^2 39.4%), but the overall results still remain similar. %EWL was significantly higher in those who have undergone RYGB (SMD 0.71, 95% CI 0.44 to 0.98) compared to SG (Fig. 10).

Seven studies [9, 11, 12, 14–16, 19] analyzed pre- and post-intervention BMI in patients undergoing SG and RYGB (Fig. 11). The pre-intervention BMI values between RYGB (mean 37.2 SD 4.3) and SG (mean 37.6 SD 4.7) groups were compared to ensure that there are no baseline differences. No

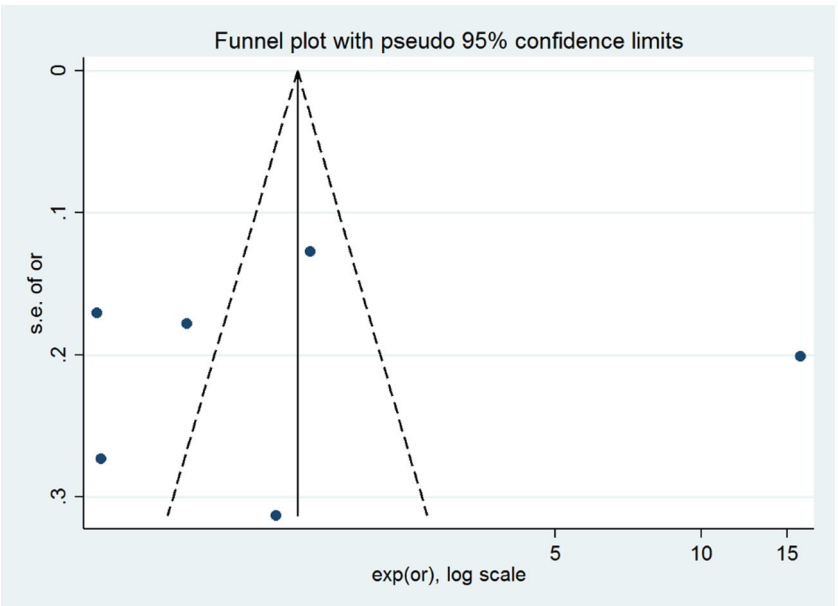

Fig. 6 Funnel plot for resolution/improvement of T2DM in patients undergoing Roux-en-Y gastric bypass and sleeve gastrectomy

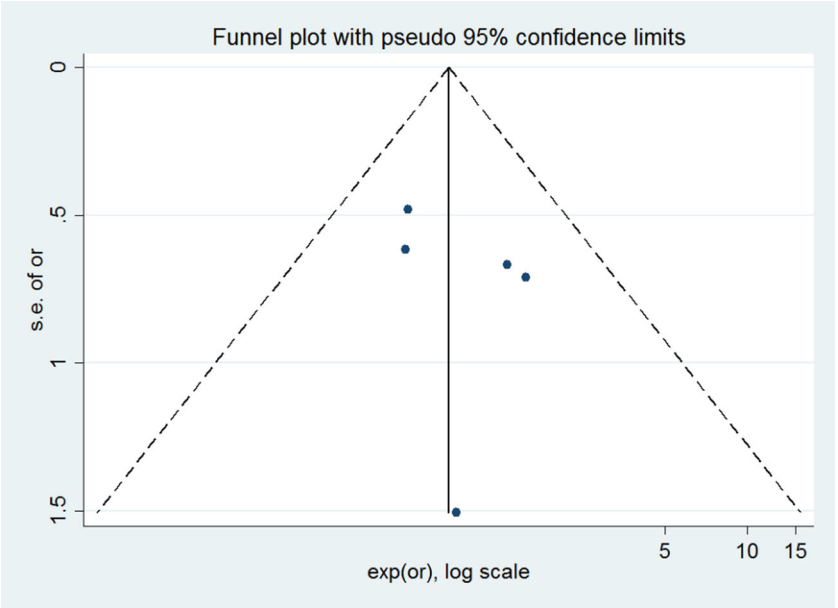

Fig. 7 Funnel plot for resolution/improvement of T2DM in patients undergoing Roux-en-Y gastric bypass and sleeve gastrectomy, excluding Lee et al. (2011)

significant difference was observed ($p = 0.944$) and the post-intervention BMI values were unlikely to be biased due to pre-intervention BMI. The analysis of pooled difference in mean post-intervention BMI contained 270 RYGB and 267 SG patients. Post-intervention BMI was significantly lower in those who have undergone RYGB (SMD − 0.58, 95% CI − 0.92 to − 0.24) compared to SG. High heterogeneity was observed (I^2 73.1%). Sensitivity analysis was performed by excluding Du et al. [12]. Post-intervention BMI was significantly lower in those who have undergone RYGB (SMD − 0.42, 95% CI − 0.61 to − 0.22) compared to SG. No heterogeneity was observed (I^2 0%) (Fig. 12).

Only two studies compared RYGB with non-surgical interventions [10, 17]. The analysis contained 91 RYGB and 93 non-surgical intervention patients. Post-intervention BMI was lower in those who have undergone RYGB (SMD − 2.22, 95% CI − 5.24 to 0.81) compared to non-surgical intervention, but statistical significance was not reached. The heterogeneity was very high (I^2 98%).

Type 2 Diabetes Mellitus Resolution or Improvement

Among patients who underwent SG in our series, 6.7–78.6% of patients had T2DM resolution [9, 11, 14, 19, 20], while a

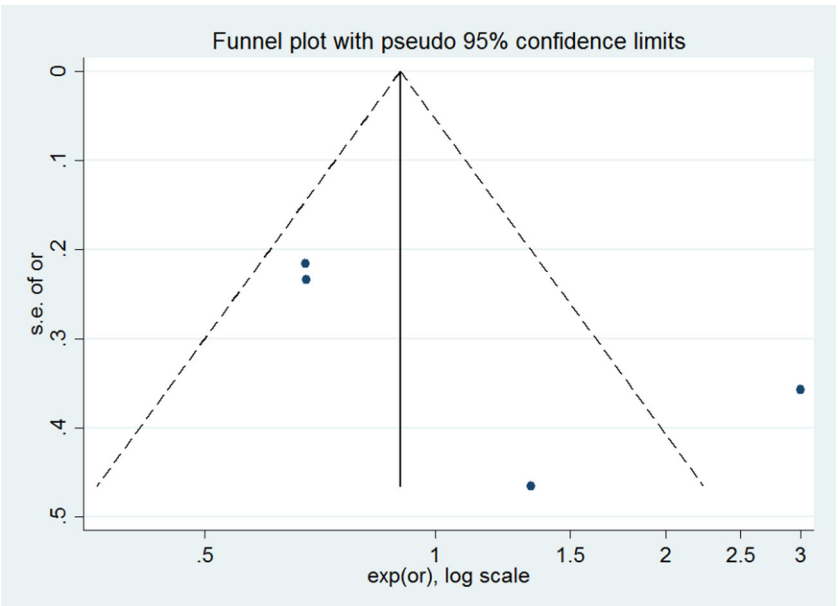

Fig. 8 Funnel plot for resolution of HTN in patients undergoing Roux-en-Y gastric bypass and sleeve gastrectomy

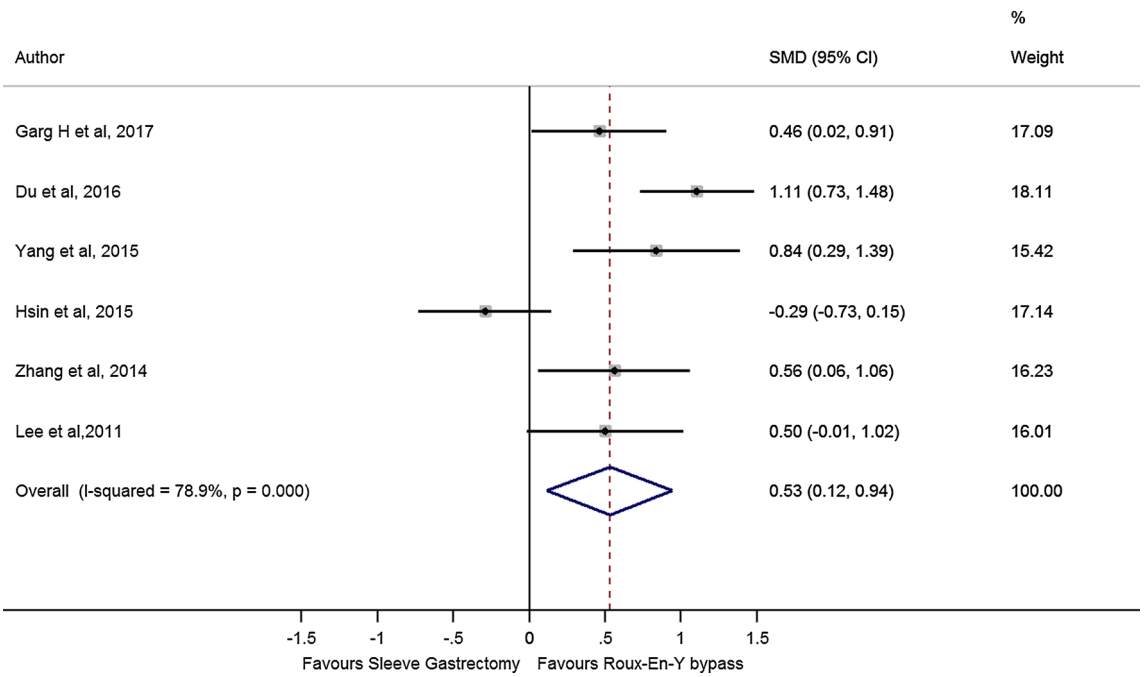

Fig. 9 %EWL in patients undergoing Roux-en-Y gastric bypass and sleeve gastrectomy. Forest plot showing standardized mean difference and 95% Confidence Interval (CI)

further 17.9–76.5% had T2DM improvement/partial resolution [11, 14, 20]. Among patients who underwent RYGB, 17–93% had T2DM resolution [9–11, 13, 14, 17–19], while T2DM improvement/partial resolution occurred in a further 11.1–63.2% of patients [10, 11, 13, 14].

Four studies [9, 11, 14, 19] reported on T2DM resolution after SG versus RYGB (Fig. 13). The analysis of pooled T2DM resolution contained 122 RYGB and 119 SG patients. T2DM resolution was favorable in those who underwent RYGB (pooled OR 1.54, 95% CI 0.39–6.06) compared to

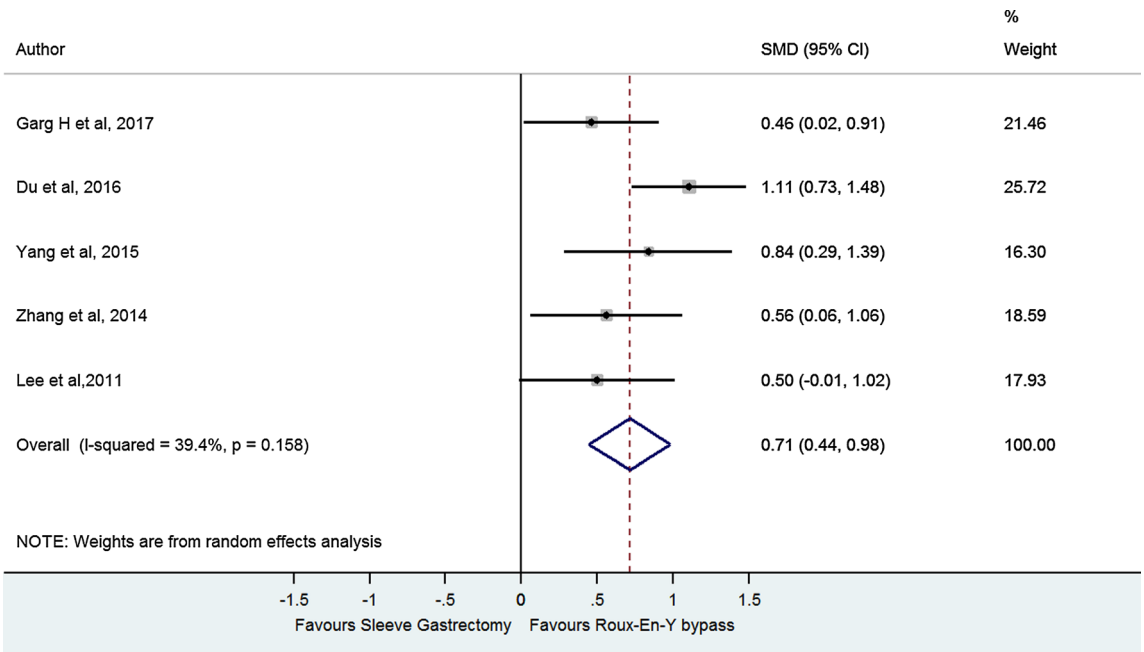

Fig. 10 %EWL in patients undergoing Roux-en-Y gastric bypass and sleeve gastrectomy. Forest plot showing standardized mean difference and 95% confidence interval (CI), excluding Hsin et al. (2015)

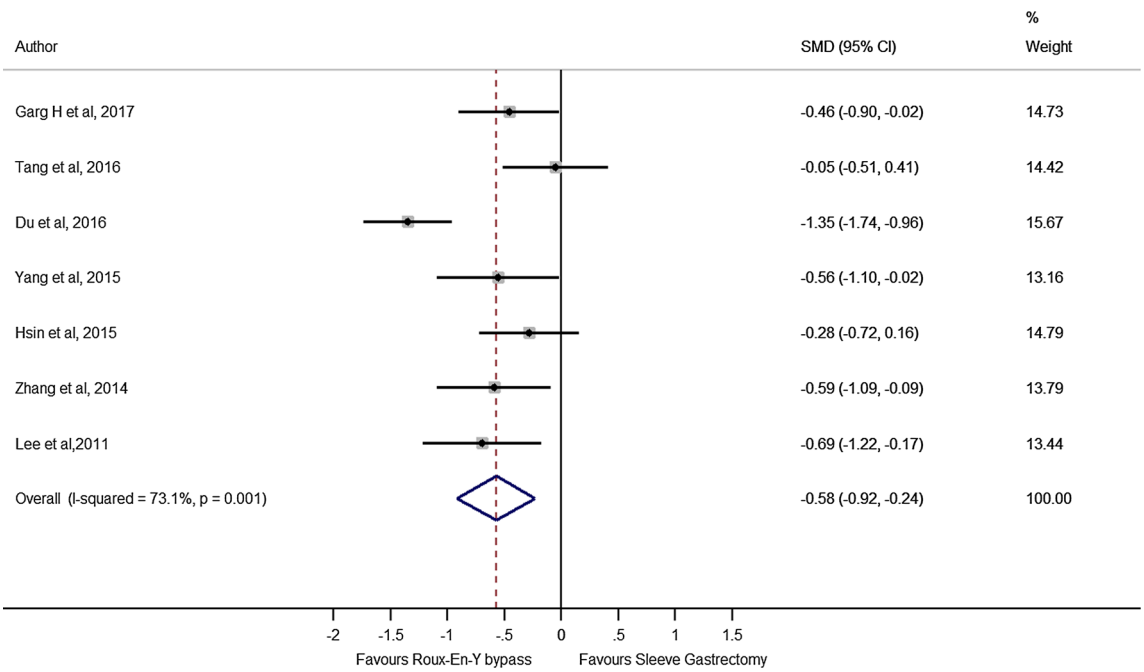

Fig. 11 Post-intervention BMI in patients undergoing Roux-en-Y gastric bypass and sleeve gastrectomy. Forest plot showing standardized mean difference and 95% confidence interval (CI)

SG, although not statistically significant. Six studies [9, 11, 12, 14, 16, 19] reported on T2DM resolution and/or improvement after SG versus RYGB (Fig. 14). The analysis of pooled T2DM resolution/improvement contained 151 RYGB and 144 SG patients. T2DM resolution/improvement was favorable in those who have undergone RYGB (pooled OR 1.39, 95% CI 0.53 to 3.67) compared to SG, although not statistically significant. Moderately high heterogeneity was observed (I^2 65%).

A sensitivity analysis was performed for T2DM resolution/improvement by excluding the study by Lee et al. [19] which appears to be the cause of heterogeneity.

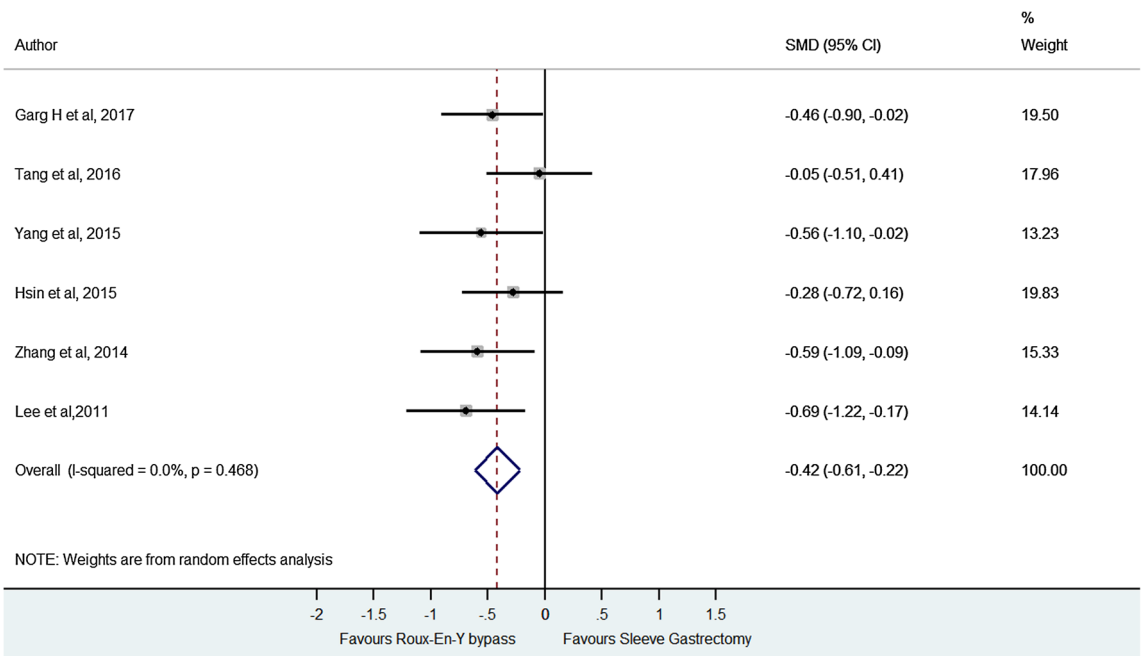

Fig. 12 Post-intervention BMI in patients undergoing Roux-en-Y gastric bypass and sleeve gastrectomy. Forest plot showing standardized mean difference and 95% confidence interval (CI), excluding Du et al. (2016)

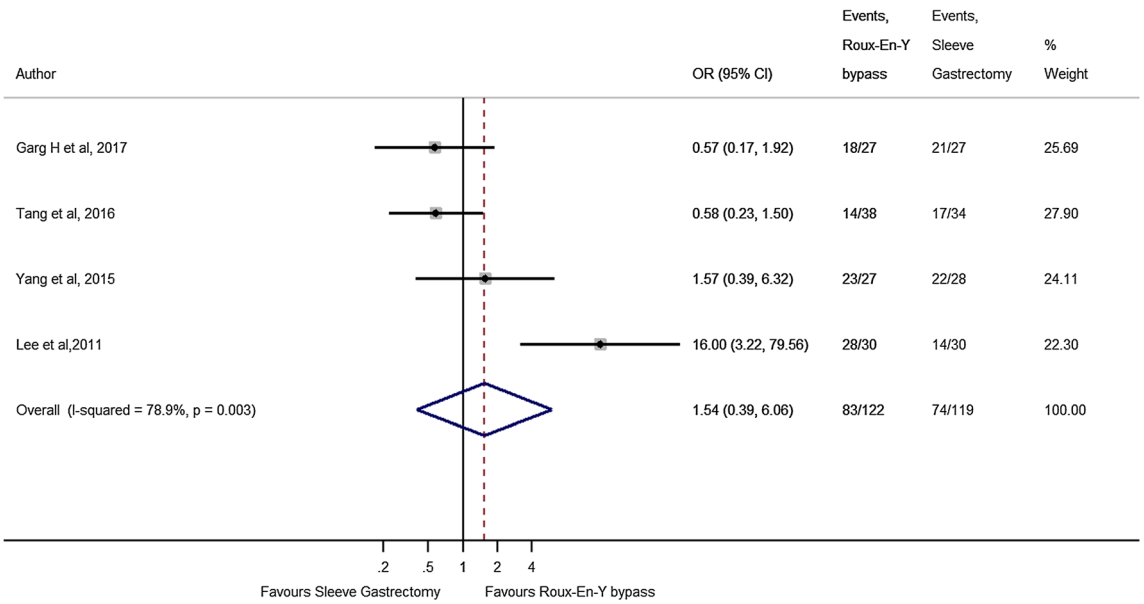

Fig. 13 Resolution of T2DM in patients undergoing Roux-en-Y gastric bypass and sleeve gastrectomy. Forest plot showing odds ratio (OR) and 95% confidence interval (CI)

After excluding the study by Lee et al. [19], the heterogeneity improved (I^2 0%), but T2DM resolution/improvement was no longer favorable in those who have undergone RYGB (pooled OR 0.82, 95% CI 0.46 to 1.45) compared to SG, although this was also not statistically significant (Fig. 15).

Hypertension Resolution

After SG, HTN resolved in 9.4–37.5% of patients [9, 12, 14, 16], while HTN resolved in 12.5–35% of patients after RYGB [9, 12–14, 16]. Four studies [9, 12, 14, 16] reported on HTN resolution after SG versus RYGB (Fig. 14).

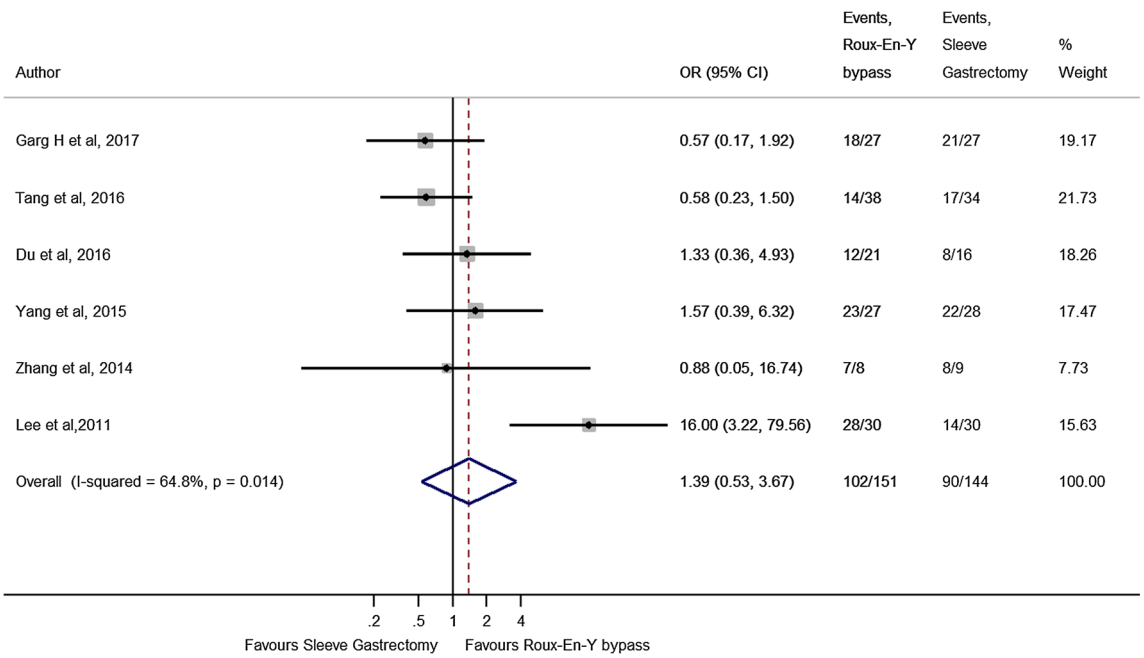

Fig. 14 Resolution/improvement of T2DM in patients undergoing Roux-en-Y gastric bypass and sleeve gastrectomy. Forest plot showing odds ratio (OR) and 95% confidence interval (CI)

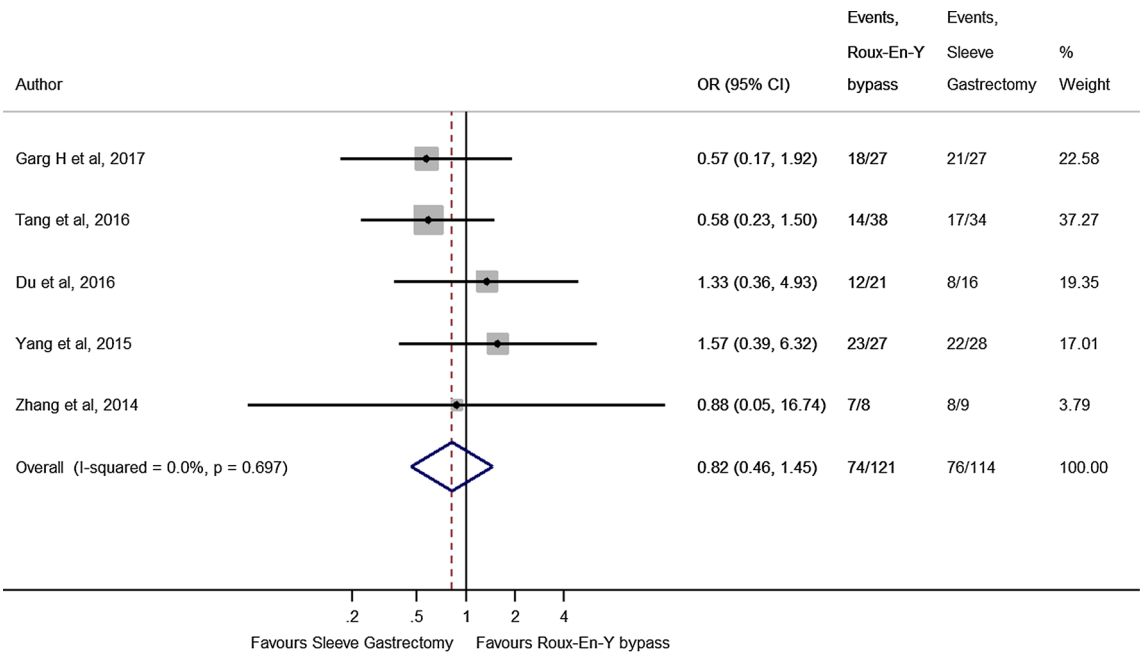

Fig. 15 Resolution of T2DM in patients undergoing Roux-en-Y gastric bypass and sleeve gastrectomy. Forest plot showing odds ratio (OR) and 95% confidence interval (CI), excluding Lee et al. (2011)

The analysis of pooled HTN resolution contained 59 RYGB and 55 SG patients. HTN resolution was not significantly different between patients who have undergone SG versus RYGB (pooled OR 0.96, 95% CI 0.44 to 2.11). No heterogeneity was observed (I^2 0%) (Fig. 16).

Post-Operative Complications

Four studies in our series reported on the post-operative complications of SG versus RYGB [9, 12, 14, 16]. RYGB had more post-operative complications, up to 15.6% [16]

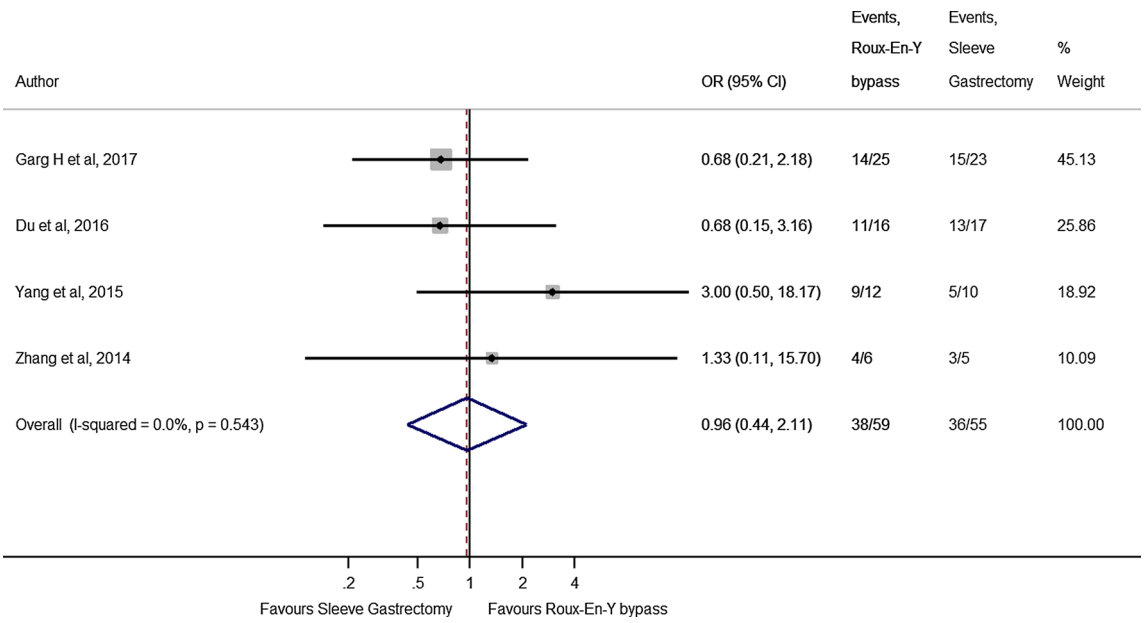

Fig. 16 Resolution of hypertension in patients undergoing Roux-en-Y gastric bypass and sleeve gastrectomy. Forest plot showing odds ratio (OR) and 95% confidence interval (CI)

compared to 7.5% [9] for SG, although none of the reported differences were statistically significant. Commonly reported complications post SG included staple line bleeding and gastro-esophageal reflux, while complications post RYGB included internal herniation, gastro-jejunal leak or stenosis, and dumping syndrome.

Discussion

Among the numerous surgical techniques of metabolic surgery, SG, RYGB, and adjustable gastric banding are the three most commonly performed bariatric/metabolic procedures in Asia [24]. While SG has become the most commonly performed metabolic surgery worldwide, largely due to its relative simplicity and good results [24], RYGB is still widely regarded as the gold standard for weight loss and resolution of obesity-related comorbidities. However, RYGB has significantly more post-operative complications compared to SG, which includes post-operative mortalities, major morbidities, and reoperation [25, 26].

Our meta-analysis shows that there is significantly greater %EWL and improvement in BMI after RYGB compared to SG, and this is consistent with other meta-analysis of mainly Caucasian studies [22, 26–28]. This may be due to the fact that RYGB not only restricts food and calorie intake, but also bypasses the duodenum and proximal jejunum, and hence decreases the absorption of nutrients.

In an analysis of both T2DM resolution and pooled T2DM resolution/improvement between LSG and RYGB, and sensitivity analysis with study homogeneity, there does not appear to be a significant difference in the rate of T2DM resolution/improvement between the two procedures. This is in contrast to what is generally observed, whereby the rate of T2DM remission after RYGB is generally higher than that of SG, as noted in a review by Lee et al. [29]. This is also in contrast to findings of various meta-analysis of mainly Caucasian studies, in which better DM resolution or control was noted after RYGB compared to SG [25–27].

One weakness of this meta-analysis is the great variation in the duration of follow-up after metabolic surgery, which may bring into question the durability of the effects post SG. The only study in our series comparing the long-term effects of SG versus RYGB is by Zhang et al. [16]. It had a follow-up of 5 years, and reported significantly greater %EWL with RYGB compared to SG, but similar rates of T2DM and hypertension resolution or improvement. In a similar study in a Caucasian population, Schauer et al. [6] reported that at 5 years, the reduction in body weight was greater with RYGB than SG. While both operations were similar for achieving a glycated hemoglobin of 6% or less at 5 years, patients who had undergone RYGB were on less medications than those who had undergone SG. A meta-analysis of mid- and long-term (> 3 and 5 years, respectively) outcomes by Shoar et al. [28] did not find any significant difference between the two procedures for comorbidity resolution, but found that RYGB has better weight loss in the long-term.

HTN is the most common comorbidity in obese patients, although exactly how obesity results in hypertension is unknown [27]. In our study, there is no difference in the resolution of HTN after RYGB versus SG. This is in contrast to findings in Caucasian studies in which HTN resolves significantly more often after RYGB compared to SG [25, 27].

One important question that remains is whether all "Asians" are the same. While the majority of the studies are from China and Taiwan, studies in this review included Chinese, Taiwanese, and Indians, which clearly do not make a homogeneous genetic population. For instance, Indians have greater susceptibility to myocardial infarction than Chinese [30]. Hence this may raise doubts as to whether this study's findings may be applicable to all "Asians," such as Malays.

The differing definitions of T2DM and HTN resolution or improvement, and the lack of data on weight loss or T2DM resolution/improvement in some included studies, is another weakness. Even among studies that report T2DM resolution/improvement, some did not record the pre-intervention HbA1c [9, 12, 16], and others [11, 12, 16, 19] did not record the duration of diabetes prior to intervention; factors that would affect the likelihood of T2DM resolution/improvement after metabolic surgery.

Just as obesity and T2DM have different disease patterns in Asians compared to Caucasians, the outcomes after metabolic surgery differ in Asians. As we perform more metabolic surgery for Asian patients of lower BMI predominantly for metabolic syndrome, the findings of this study could shape the operation we choose. RYGB has better %EWL compared to SG, and will likely remain the gold standard of metabolic surgery, especially in morbidly obese patients with metabolic syndrome in whom weight loss is the primary objective. However in Asian patients in whom metabolic surgery is performed for metabolic syndrome rather than weight loss per se, SG could be the operation of choice as it offers just as good resolution of T2DM and HTN as RYGB, is a technically easier operation to perform, and is associated with lesser morbidities and nutritional deficiencies [31].

Conclusion

While RYGB results in better weight loss compared to sleeve gastrectomy, the rate of T2DM resolution/improvement and improvement of HTN appears to be similar between RYGB compared to SG in Asian patients in the short term. In Asian patients without symptoms of gastro-esophageal reflux disease in whom metabolic surgery is performed mainly for

T2DM and metabolic syndrome, SG may be considered as the surgery of choice. Further long-term, well-designed randomized studies are warranted, especially in the context of resolution/improvement of diabetes and other comorbidities.

Compliance with Ethical Standards

Conflict of Interest The authors declare that they have no conflict of interest.

Ethical Approval Statement This article does not contain any studies with human participants or animals performed by any of the authors.

Informed Consent Statement Does not apply.

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