Systematic Review and Meta-Analysis

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Comparison of safety and effectiveness between laparoscopic mini-gastric bypass and laparoscopic sleeve gastrectomy

A meta-analysis and systematic review

Fu-Gang Wang, MD[a,b], Zhao-Peng Yu, MD[a,b], Wen-Mao Yan, MD[b], Ming Yan, MD[b], Mao-Min Song, MD, PhD[b,*]

Abstract

Background: The laparoscopic mini-gastric bypass is a newly emerged surgical procedure in recent years. Owe to safe and simple process and effective outcomes, laparoscopic mini-gastric bypass has quickly become one of the most popular procedures in some countries. The safety and effectiveness of laparoscopic mini-gastric bypass versus laparoscopic sleeve gastrectomy remain unclear.

Methods: A systematic literature search was performed in PubMed, Embase, Cochrane library from inception to May 20, 2017. The methodological quality of Randomized Controlled Trials and non-Randomized Controlled Trials were, respectively, assessed by Cochrane Collaboration's tool for assessing risk of bias and Newcastle–Ottawa scale. The meta-analysis was performed by RevMan 5.3 software.

Results: Patients receiving mini-gastric bypass had a lot of advantageous indexes than patients receiving sleeve gastrectomy, such as higher 1-year EWL% (excess weight loss), higher 5-year EWL%, higher T2DM remission rate, higher hypertension remission rate, higher obstructive sleep apnea (OSA) remission rate, lower osteoarthritis remission rate, lower leakage rate, lower overall late complications rate, higher ulcer rate, lower gastroesophageal reflux disease (GERD) rate, shorter hospital stay and lower revision rate. No significant statistical difference was observed on overall early complications rate, bleed rate, vomiting rate, anemia rate, and operation time between mini-gastric bypass and sleeve gastrectomy.

Conclusion: Mini-gastric bypass is a simpler, safer, and more effective bariatric procedure than laparoscopic sleeve gastrectomy. Due to the biased data, small sample size and short follow-up time, our results may be unreliable. Large sample and multicenter RCT is needed to compare the effectiveness and safety between mini-gastric bypass and sleeve gastrectomy. Future study should also focus on bile reflux, remnant gastric cancer, and long term effectiveness of mini-gastric bypass.

Abbreviations: CS = cohort study, EWL = excess weight loss, GERD = gastroesophageal reflux disease, MGB = mini-gastric bypass, NOS = Newcastle–Ottawa Scale, OSA = obstructive sleep apnea, RCT = randomized control trial, RR = risk ratio, SG = sleeve gastrectomy, T2DM = type 2 diabetes mellitus.

Keywords: bariatric, mini-gastric bypass, obesity, omega gastric bypass, single anastomosis gastric bypass, sleeve gastrectomy

1. Introduction

More and more people suffer from morbid obesity because of the increased living standard and decreased physical exercise in the past several decades. According to a recent report based on USA population, the incidence of obese among adults even reaches up to 34.9%.[1] Between 1980 and 2008, the mean global body mass index (BMI) was increasing by 0.4–0.5 kg/m^2 per decade for both men and women.[2] Obesity and related comorbidities reduce life expectancy[3] and add economic burden,[4] which highlights the significance of bariatrics. The most effective therapy to treat obese and related comorbidities is bariatric surgery, in which Roux-en-Y gastric bypass (RYGBP) and sleeve gastrectomy (SG) are two most popular procedures[5,6]. Introduced by D.W. Hess et al in 1988 as part of the biliopancreatic diversion,[7,8] SG is one of the most popular procedures (37%) in the world.[9] SG is a technically less complex procedure with short learning curve and effective weight loss,[8] but it suffers from two outstanding disadvantages including high risk of weight regain and gastroesophageal reflux disease (GERD).[10,11] Mini-gastric bypass (MGB), also known as single anastomosis gastric bypass or omega gastric bypass, is a newly emerged procedure originated from Rutledge.[12] Due to safe and simple process as well as effective outcomes, MGB has quickly become one of the most popular procedures in many countries.[13,14] Despite of popular status, the extension of MGB is still limited by some concerns such as gastric and oesophageal bile reflux, marginal ulcer, poor

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[a] Capital Medical University, [b] Department of General Surgery, Beijing Tiantan Hospital, Beijing, China.

[*] Correspondence: Mao-Min Song, Department of General Surgery, Beijing Tiantan Hospital, Capital Medical University, Tiantanxili Road, Beijing 100050, P. R. China (e-mail: songmaomin@163.com).

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follow-up, and remnant gastric cancer.[15] During the past decade, many observational studies have proved the considerable short-term and long-term outcomes of MGB,[16,17] but comparative studies between MGB and SG are still scarce. For this reason, we conducted a meta-analysis to help the surgeon make a better selection between MGB and SG.

2. Material and methods

2.1. Search strategy

A systematic literature search was conducted in PubMed, Embase, and Cochrane library from inception to May 20, 2017. The search strategy for Medline is as follows which was applied to other databases:" ((((((((((mason's loop[Title/Abstract]) OR mini-gastric bypass[Title/Abstract]) OR mini-gastric bypass[Title/Abstract]) OR single anastomosis gastric bypass[Title/Abstract]) OR single-anastomosis gastric bypass [Title/Abstract]) OR single anastomosis (mini-) gastric bypass [Title/Abstract]) OR one anastomosis (mini-) gastric bypass[Title/Abstract]) OR one anastomosis gastric bypass[Title/Abstract]) OR one-anastomosis gastric bypass[Title/Abstract]) OR omega gastric bypass[Title/Abstract]) OR omega-loop bypass[Title/Abstract]) OR omega loop bypass[Title/Abstract]" Randomized control trials (RCTs), two-arm prospective studies, retrospective studies, and cohort studies were included. The reference list of potential studies was manually searched for eligibility by two independent reviewers, and if there was disagreement regarding inclusion, a third reviewer was consulted. Our study was approved by Ethics Committee of Beijing Tiantan Hospital.

2.2. Inclusion criteria

(1) Comparative studies between MGB and SG; (2) patients were adults, with age ranging from 20 to 70 years old; (3a) at least one of the following concerned endpoints was included: operation time, mortality, overall early complications, specific early complications, overall late complications, specific late complications, hospital stay, revision rate, remission rate of comorbidities,1-year %EWL or 5-year %EWL.

2.3. Exclusion criteria

(1) Observational studies or comparative studies between MGB and non-SG; (2) studies including adolescents or elderly patients; (3) no concerned endpoints were included; (4) duplicate studies; (5) low quality studies.

2.4. Data extraction

Data extraction was cross-checked synchronously between two authors to rule out any discrepancy. The third author made a final decision for the discrepancy. The following data were independently extracted for each included study: author, publication year, study design, sample size, proportion of female, patients' mean age, preoperative BMI, operation time, blood loss, 1-year follow-up rate, mortality, overall early complications rate, specific early complications rate (leakage, bleed, abscess, dyspepsia, and wound infection), overall late complications rate, specific late complications rate (ulcer, stenosis, hypoalbuminemia, vomiting, anemia, reflux, internal hernia, GERD, malnutrition, and cholelithiasis), hospital stay, revision rate, remission rate of comorbidities (T2DM, hypertension, OSA, ostearthritis), 1-year %Excess Weight Loss (EWL) and 5-year %EWL. If data sets were overlapped or duplicated, only the most recent data were included. If necessary, the authors were contacted for additional information.

2.5. Assessment of methodological quality

The methodological quality of included cohort studies was performed by NOS (Newcastle–Ottawa scale). We modified NOS according to our previous study. The concrete content included selection of patients, comparability, and assessment of results. When scored ≤ 5, the cohort study was assessed as low quality and excluded from our meta-analysis; when scored>5, the study was assessed as high quality and included in our meta-analysis. The methodological quality of included RCTs was performed by the Cochrane Collaboration's tool for assessing risk of bias. The concrete content included random sequence generation; allocation concealment; blinding of participants and personnel; blinding of outcome assessment; incomplete outcome data; selective reporting; other sources of bias.

2.6. Endpoints

The primary endpoints included 1-year %EWL, 5-year %EWL, and remission rate of comorbidities (T2DM, hypertension, OSA, ostearthritis). The secondary endpoints included overall early complications rate, leakage rate, and postoperative bleed rate, overall late complications rate, ulcer rate, vomiting rate, anemia rate, GERD rate, hospital stay, and revision rate. The last endpoint was operation time.

2.7. Statistical analysis

Statistical analysis was carried out by RevMan 5.3 software. Risk ratio (RR) was calculated to express the effect size of dichotomous variables such as remission rate of comorbidities, overall early complications rate, leakage rate, postoperative bleed rate, overall late complications rate, ulcer rate, vomiting rate, anemia rate, GERD rate, and revision rate. Standard mean difference (SMD) was calculated to express the effect size of continuous variables such as 1-year %EWL, 5-year %EWL hospital stay, and operation time. I^2 statistic was used to show the heterogeneity between studies. The random effects model was used when there was significant heterogeneity between studies ($I^2 \geq 50\%$); on the contrary, the fixed effect model was used when there was no significant heterogeneity between studies ($I^2 < 50\%$).

3. Results

One study[18] was obtained by referring the reference list of included studies. One low quality paper[19] was excluded after assessment of methodological quality. At last, a total of 12 cohort studies[8,11,13,18,20–27] and 2 RCTs[28,29] were included in our meta-analysis (The flowchart of selecting procedure is shown in Fig. 1). Our meta-analysis included 3862 patients (1998 patients in MGB group, 1864 patients in SG group, respectively). There were 2 studies[25,27] on super obese patients (preoperative BMI > 50 kg/m^2) and 3 studies[13,18,24] on the patients with preoperative T2DM. The basic characteristics of included studies are presented in Table 1. The bias of risk of cohort studies and RCTs are presented in Table 2 and Figure 2, respectively.

Table 1

Basic characteristics of included studies (mini-gastric bypass/sleeve gastrectomy).

Author	Year	Study design	Sample size	Gender (F)	Age, years	Preoperative BMI, kg/m^2	Operation time, min	Blood loss, mL	Follow rate (1 year)
Kansou et al[21]	2016	C	136/136	93.4%/91.9%	41/41	43/43	–	–	88.4%
Jammu et al[11]	2016	C	473/339	70.4%/45.4%	46.5/23	56.5/35	57.5±8.25/60±7.5	–	94.7%
Kular et al[22]	2014	C	104/118	–	–	44/42	52±20.2/76.6±28.3	–	–
Lee et al[29]	2014	RCT	30/30	73.3%/68.8%	44.6/46.4	30.2/31	–	–	80%
Musella et al[13]	2016	C	96/110	39.6%27.3%	48.5/49.2	48.3/48.1	–	–	63.7%
Lee et al[23]	2015	C	519/519	78/75	35.9/36	37.4/37.5	117.2±33.3/113.5±31.1	37.9±26.6/49.1±100.9	96%/81%
Seetharamaiah et al[28]	2016	RCT	101/100	61%/65%	42.9/39.9	44.3/44.6	64.8±10.6/44.8±10.6	–	94%
Plamper et al[27]	2017	C	169/118	71.6%/61%	43.2/43.4	54.1/54.6	81.7±25.3/112.1±33.5	–	90.8%/78.7%
Madhok et al[25]	2016	C	19/56	47%/55%	45/51	67/65	92±31.5/75±50.5	–	100%
Yang et al[18]	2014	C	89/32	76%/41%	32.1/33.9	41.7/42.4	–	–	–
Lee et al[24]	2013	C	17/12	–	32	41.7/39.6	–	–	100%
Musella et al[31]	2014	C	80/175	48%/70%	34.8/38.25	50.8/47.9	–	–	94%
Ding et al[20]	2011	C	12/5	15.4%/80%	46/30	34.7/43.8	–	–	–
Milone[26]	2015	C	74/86	62.2%/53.5%	34.9/33.7	47.3/46	–	–	–

C=cohort study, F=female, RCT=randomized controlled study.

3.1. Primary endpoints

3.1.1. One-year EWL%. A total of 7 studies[13,18,21,22,25,27,28] reported the 1-year EWL% in our meta-analysis (Table 3). I^2= 81%, so the random effects model was used to pool the 7 studies. The result indicated MGB group had a higher 1-year %EWL than SG group (P=.005) (Fig. 3A).

3.1.2. 5-year EWL%. A total of 3 studies[22,23,29] reported the 5-year EWL% in our meta-analysis (Table 3). Since there were 2 studies involving overlap of data sets,[23,29] the most recent study was used.[23] I^2=76%, so the random effects model was used to pool the 2 studies. The result indicated MGB group had a higher 5-year %EWL than SG group (P<.001) (Fig. 3B).

3.2. Remission rate of T2DM

A total of 10 studies[8,11,13,20–22,24,25,28,29] reported the remission rate of T2DM in our meta-analysis (Table 3). As there were 4 studies with overlap of data sets,[8,13,24,29] the 2 most recent studies were used.[13,29] I^2=59%, so the random effects model was used to pool the 8 studies.[11,13,20–22,25,28,29] The result indicated MGB group had a higher remission rate of T2DM than SG group (P=.002) (Fig. 3C).

3.3. Remission rate of hypertension

A total of 7 studies[11,21,22,25,26,28,29] reported the remission rate of hypertension in our meta-analysis (Table 3). I^2=48%, so the random effects model was used to pool the 6 studies. The result indicated MGB group had a higher remission rate of hypertension than SG group (P=.02) (Fig. 3D).

3.4. Remission rate of OSA

A total of 3 studies[21,22,25] reported the remission rate of OSA in our meta-analysis (Table 3). I^2=0%, so the fixed effects model was used to pool the 3 studies. The result indicated MGB group had a higher remission rate of OSA than SG group (P=.03) (Fig. 3E).

3.5. Remission rate of ostearthritis

A total of 2 studies[8,21] reported the remission rate of osteoarthritis in our meta-analysis (Table 3). I^2=26%, so the fixed effects model was used to pool the 2 studies. The result indicated MGB group had a lower remission rate of ostearthritis than SG group (P=.008) (Fig. 3F).

3.6. Secondary endpoints

3.6.1. Overall early complications rate. A total of 7 studies[8,13,21,22,23,25,27] reported overall early complications rate in our meta-analysis (Table 4). Since there were 2 studies with overlap of data sets[8,13] overlapped, the most recent study was used. I^2=51%, so the random effects model was used to pool the 6 studies. No difference of overall early complications rate was found between MGB and SG (P=.28) (Fig. 4A).

3.6.2. Leakage rate. A total of 5 studies[11,13,21,27,28] reported leakage rate in our meta-analysis (Table 4). I^2=41%, so the fixed effects model was used to pool the 5 studies. The result indicated MGB group had a lower leakage rate than SG group (P=.02) (Fig. 4B).

3.6.3. Bleed rate. A total of 6 studies[11,13,21,22,27,28] reported bleed rate in our meta-analysis (Table 4). I^2=0%, so the fixed effects model was used to pool the 6 studies. No difference of leakage rate was found between MGB and SG (P=.95) (Fig. 4C).

3.6.4. Overall late complications rate. A total of 3 studies[8,22,25] reported overall late complications rate in our meta-analysis (Table 4). I^2=0%, so the fixed effects model was used to pool the 3 studies. The result indicated MGB group had a lower overall late complications rate than SG group (P=.02) (Fig. 4D).

3.6.5. Ulcer rate. A total of 6 studies[11,21,22,25,28,29] reported ulcer rate in our meta-analysis (Table 4). I^2=0%, so the fixed effects model was used to pool the 6 studies. The result indicated MGB group had a higher ulcer rate than SG group (P=.001) (Fig. 4E).

3.6.6. Vomiting rate. A total of 3 studies[11,25,28] reported vomiting rate in our meta-analysis (Table 4). I^2=0%, so the fixed effects model was used to pool the 3 studies. No difference of vomiting rate was found between MGB and SG (P=.36 (Fig. 4F).

3.6.7. Anemia rate. A total of 2 studies[11,22] reported anemia rate in our meta-analysis (Table 4). I^2=0%, so the fixed effects

Table 2

Assessment of methodological quality of cohort study.

Author	Choice of patients					Results			Score
	Representativeness of LMGB group	Representativeness of LSG group	Operation style was obtained from operation records	All patients suffered morbid obese or T2DM	Comparability	Results were objective	Follow-up time was 1year or longer	1 year follow-up rate was 60% or higher	
Kansou et al[21]	★	★	★	★	★	★	★	★	8
Jammu et al[11]	★	★	★	★		★	★	★	7
Kular et al[22]	★	★	★	★	★	★	★	★	8
Musella et al[13]			★	★	★	★	★	★	6
Lee et al[23]	★	★	★	★	★	★	★	★	8
Plamper et al[27]			★	★	★	★	★	★	6
Madhok et al[25]			★	★	★	★	★	★	6
Yang et al[18]	★	★	★	★		★	★		6
Lee et al[24]			★	★	★	★	★	★	6
Musella et al[13]	★	★	★	★		★	★	★	7
Guo et al[19]			★	★		★			3
Ding et al[20]	★	★	★	★		★	★		6
Milone et al[26]	★	★	★	★	★	★	★	★	8

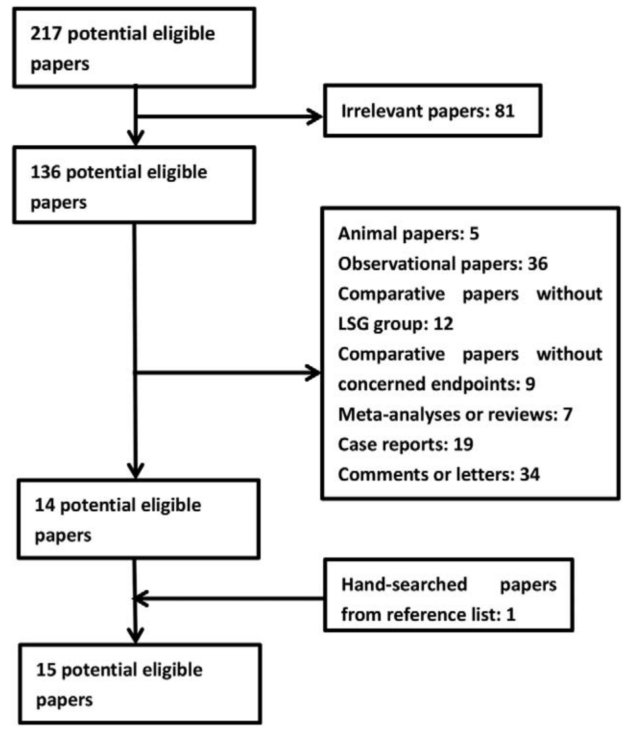

Figure 1. Flowchart of paper inclusion.

model was used to pool the 3 studies. No difference of anemia rate was found between MGB and SG ($P=.17$ (Fig. 4G).

3.6.8. GERD rate. A total of 4 studies[11,22,25,28] reported GERD rate in our meta-analysis (Table 4). $I^2=52\%$, so the random

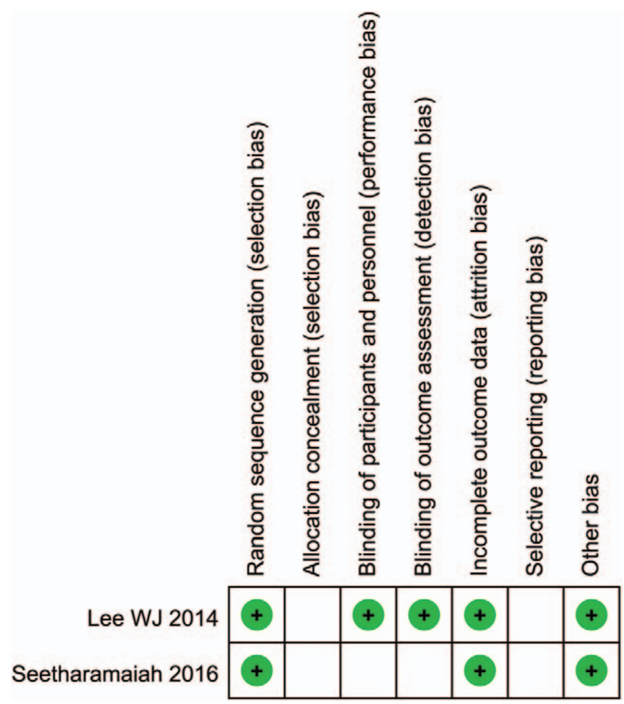

Figure 2. Risk of bias of included RCTs. RCT=randomized control trials.

Table 3

Resolution of comorbidities, %EWL and weight regain of included studies (mini-gastric bypass/sleeve gastrectomy).

		T2DM				Hypertension				OSA				Ostearthritis						
Author	Sample size	R1	N1	R0	N0	R1	N1	R0	N0	R1	N1	R0	N0	R1	N1	R0	N0	%EWL (1 year)	%EWL (5 year)	Weight regain
Kansou et al[21]	136/136	25	2	19	2	34	8	30	9	37	3	22	7	43	22	54	8	79.3 ± 17.8/71.4 ± 19	–	–
Jammu et al[11]	473/339	59	3	13	10	41	7	14	16	–	–	–	–	–	–	–	–	92.2/53.6	–	0/48
Kular et al[22]	104/118	58	5	49	12	46	14	41	15	27	1	22	4	–	–	–	–	63 ± 21.2/69 ± 22.5	68 ± 24/51.2 ± 23	0/13
Lee et al[29]	30/30	18	12	9	21	12	4	6	11	–	–	–	–	–	–	–	–	–	22.8 ± 5.9/20.1 ± 5.3	–
Musella et al[13]	96/110	82	14	67	43	–	–	–	–	–	–	–	–	–	–	–	–	64.7 ± 22.9/52.4 ± 18.3	–	–
Lee et al[23]	519/519	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	78.2 ± 19.7/68.7 ± 30.3	–
Seetharamaiah et al[28]	101/100	41	6	36	13	34	19	37	19	–	–	–	–	–	–	–	–	66.87 ± 10.87/63.97 ± 13.24	–	–
Plamper et al[27]	169/118	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	66.2 ± 13.9/57.3 ± 19	–	–
Madhok et al[25]	19/56	4	2	9	8	1	7	4	24	2	1	7	5	–	–	–	–	58 ± 7.75/45 ± 21.5	–	–
Yang et al[18]	89/32	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	72 ± 20/67.2 ± 18.4	–	–
Lee et al[24]	17/12	12	5	7	5	–	–	–	–	–	–	–	–	–	–	–	–	37.1/31.4	–	–
Musella et al[31]	80/175	22	3	21	5	–	–	–	–	–	–	–	–	3	0	20	2	72.1%/61.4%	–	–
Ding et al[20]	12/5	7	3	1	2	–	–	–	–	–	–	–	–	–	–	–	–	65.4%/53.9%	–	–
Milone et al[26]	74/86	21	7	16	8	5	10	3	9	–	–	–	–	–	–	–	–	–	–	–

EWL = excess weight loss, N0 = Remission in LSG, N1 = Nonremission in LMGB, OSA = obstructive sleep apnea, R0 = Remission in LSG, R1 = Remission in LMGB, T2DM = type 2 diabetes mellitus.

effects model was used to pool the 4 studies. The result indicated MGB group had a lower GERD rate than SG group (P = .006) (Fig. 4H).

3.7. Hospital stay

A total of 4 studies[22,23,27,28] reported hospital stay in our meta-analysis (Table 4). $I^2 = 96\%$, so the random effects model was used to pool the 4 studies. The result indicated MGB group had a shorter hospital stay than SG group ($P = .05$) (Fig. 4I).

3.7.1. *Revision rate.* A total of 5 studies[21,22,25,27,29] reported revision rate in our meta-analysis (Table 4). $I^2 = 0\%$, so the fixed effects model was used to pool the 5 studies. The result indicated MGB group had a lower revision rate than SG group ($P < .001$) (Fig. 4J).

3.8. Operation time

A total of 6 studies[11,22,23,25,27,28] reported operation time in our meta-analysis (Table 1). $I^2 = 98\%$, so the random effects model was used to pool the 4 studies. No difference of operation time was found between MGB and SG ($P = .58$) (Fig. 4K).

4. Discussion

Proposed by Rutledge[12] in 2001, MGB has become one of the most popular surgical procedures for morbid obesity in many countries because of its high safety and effectiveness. Today, thousands of MGB cases have been reported and most of these cases showed MGB had similar or superior safety and effectiveness than SG or RYGB.[12,30–35] To our knowledge, a total of 8 large sample (≥1000), retrospective, and observational studies[12,31,33–35,36–38] have proven the safety and effectiveness advantage of MGB. However, comparative studies between MGB and SG are scarce or the sample size is too small. After RYGB, SG is now the second frequently used surgical procedure in the world. Many researches[39–41] have compared the safety and effectiveness of SG versus RYGB, and the results were variable. A meta-analysis including 62 comparative studies performed by Li et al[42] has shown patients receiving RYGB had a significantly higher percentage of excess weight loss and better resolution of hypertension, dyslipidemia, gastroesophageal reflux disease, and arthritis compared with those receiving SG. But Osland et al[43–45] have pooled the RCTs comparing RYGB with SG and concluded that SG and RYGB were comparable in weight loss outcomes, postoperative comorbid disease resolution (T2DM, hypertension, dyslipidemia, OSA, joint and musculoskeletal conditions, GERD) and early minor complications. Due to the variable results, we cannot make a conclusion about the effectiveness and safety between SG and RYGB. Large sample and multi-center RCT is needed to prove the better procedure between SG and RYGB in the future. Here, we performed a meta-analysis of MGB versus SG, in the hope of helping the bariatric surgeon make a better selection between MGB and SG.

4.1. EWL%

In the 13 included studies, the 1-year EWL% for MGB and SG were, respectively, 58% to 79.3% and 45% to 71.4%, while the 5-year EWL% were are 68% to 78.2% and 51.2% to 68.7%, respectively. We reviewed the observational studies and found a similar EWL% for MGB.[12,31,33–38] Our result indicated MGB had a superior 1-year EWL% and 5-year EWL% than SG. The maximum EWL% always occurs in 2 years after surgery

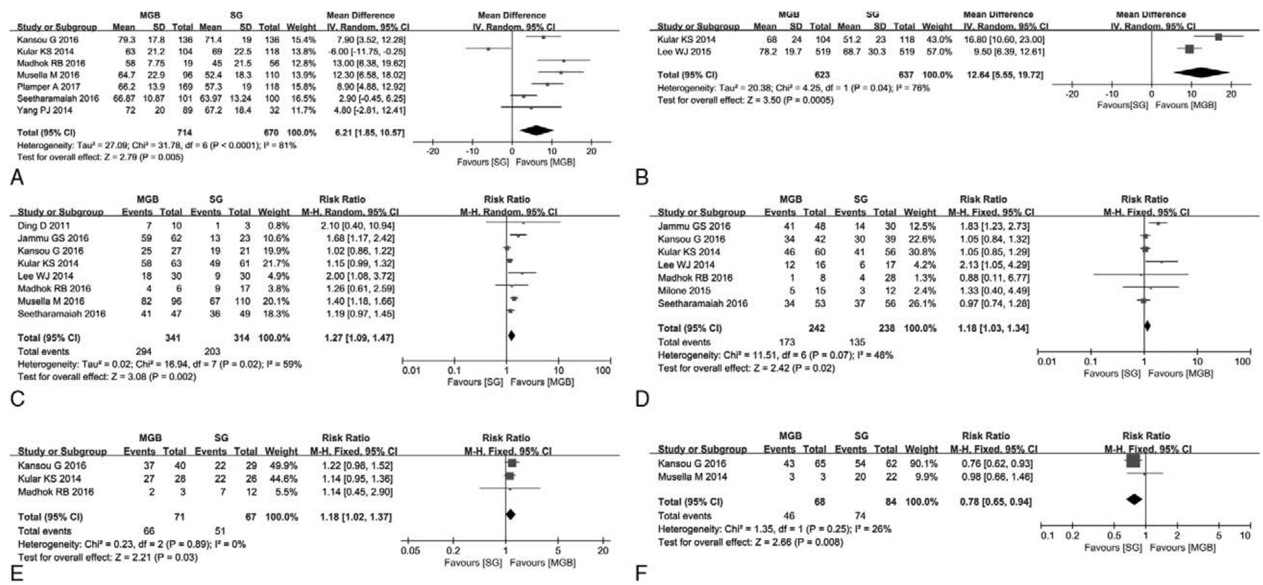

Figure 3. (A) 1 year EWL% of MGB versus SG. (B) 5 years EWL% of MGB versus SG. (C) T2DM remission rate of MGB versus SG. (D) Hypertension remission rate of MGB versus SG. (E) OSA remission rate of MGB versus SG. (F) Ostearthritis remission rate of MGB versus SG. EWL=excess weight loss, MGB=mini-gastric bypass, OSA=obstructive sleep apnea, SG=sleeve gastrectomy, T2DM=type 2 diabetes mellitus.

according to previous studies,[33,46] in view of which, future studies should compare MGB and SG in terms of 2-year or longer EWL%. Although we pooled the 5-year EWL%, minor sample size may influence the stability of the result. The higher EWL% of MGB may be due to different mechanisms between MGB and SG. As we all know, SG is a restrictive procedure, but MGB is a restrictive and malabsorptive procedure.

4.2. Remission rate of comorbidities

The most common comorbidities of morbid obesity are T2DM, hypertension, OSA and ostearthritis, among which, T2DM is the most harmful one. Remission of T2DM was defined as HbA1C level < 6.5% in 3 studies,[13,20,28] <6% in 1 study,[22] untold in 4 studies.[11,21,25,29] Remission of hypertension, OSA, and ostearthritis was defined as normalization of baseline characteristics without using drugs or continuous positive-pressure airway machine.[8,21,22,25] The overall remission rate of T2DM, hypertension, OSA, and ostearthritis was 86%, 75%, 93%, 68% for MGB and 65%, 60%, 76%, 88% for SG, respectively. Previous large sample size and observational studies on MGB showed a remission rate of 84.1% to 94%,[16,33,34,37] 52.1% to 94%,[16,33,34] 50% to 90%,[33,34] and 18% to 36.5%[33,34] for

Table 4

Mortality, morbidity and hospital stay of included studies (mini-gastric bypass/sleeve gastrectomy).

Author	Sample size	Mortality	Overall early complications	Specific early complications	Overall late complications	Specific late complications	Hospital stay	Revision
Kansou et al[21]	136/136	0/0	6/8	Leakage:7/6; bleed: 2/1	–	Ulcer:10/0; stenosis:23/0	–	0/0
Jammu and Sharma[11]	473/339	0/7	–	Leakage:0/5; bleed:2/0	–	Vomiting:0/1; anemia:23/12; reflux:2/0; GERD:3/32; internal hernia: 0/0; ulcer: 3/0; stemosis:0/0	–	–
Kular et al[22]	104/118	0/0	5/14	Dyspesia:4/8; bleed:1/4; abscess:0/1	14/26	Ulcer:1/0; GERD:2/16; anemia: 5/2; malnutrition:1/0; cholelithiasis:6/8	2.5 ± 1.3/3.4 ± 2.4	1/16
Lee et al[29]	30/30	0/0	–	–	–	Ulcer:1/0	–	1/4
Musella et al[13]	175/138		8/5	Leakage:0/1; bleed:5/3	–	–	–	–
Lee et al[23]	519/519		49/38	–	–	–	3.4 ± 2.4/3 ± 1.7	–
Seetharamaiah et al[28]	101/100	0/0	–	Wound infection:4/6; leakage:0/1; bleed:3/4	–	Vomiting:3/4; ulcer:2/0; GERD:2/3	3.2 ± 0.64/3.95 ± 0.73	–
Plamper et al[27]	169/118	1/3	5/11	Leakage:1/6; bleed: 2/1	–	–	4.5 ± 2.6/7.2 ± 5.5	2/3
Madhok et al[25]	19/56	0/0	0/3	–	2/5	GERD:1/5; ulcer:1/0; vomiting:0/3	2/2	1/10
Musella et al[31]	80/175	0/1	1/6	–	3/20	–	–	–

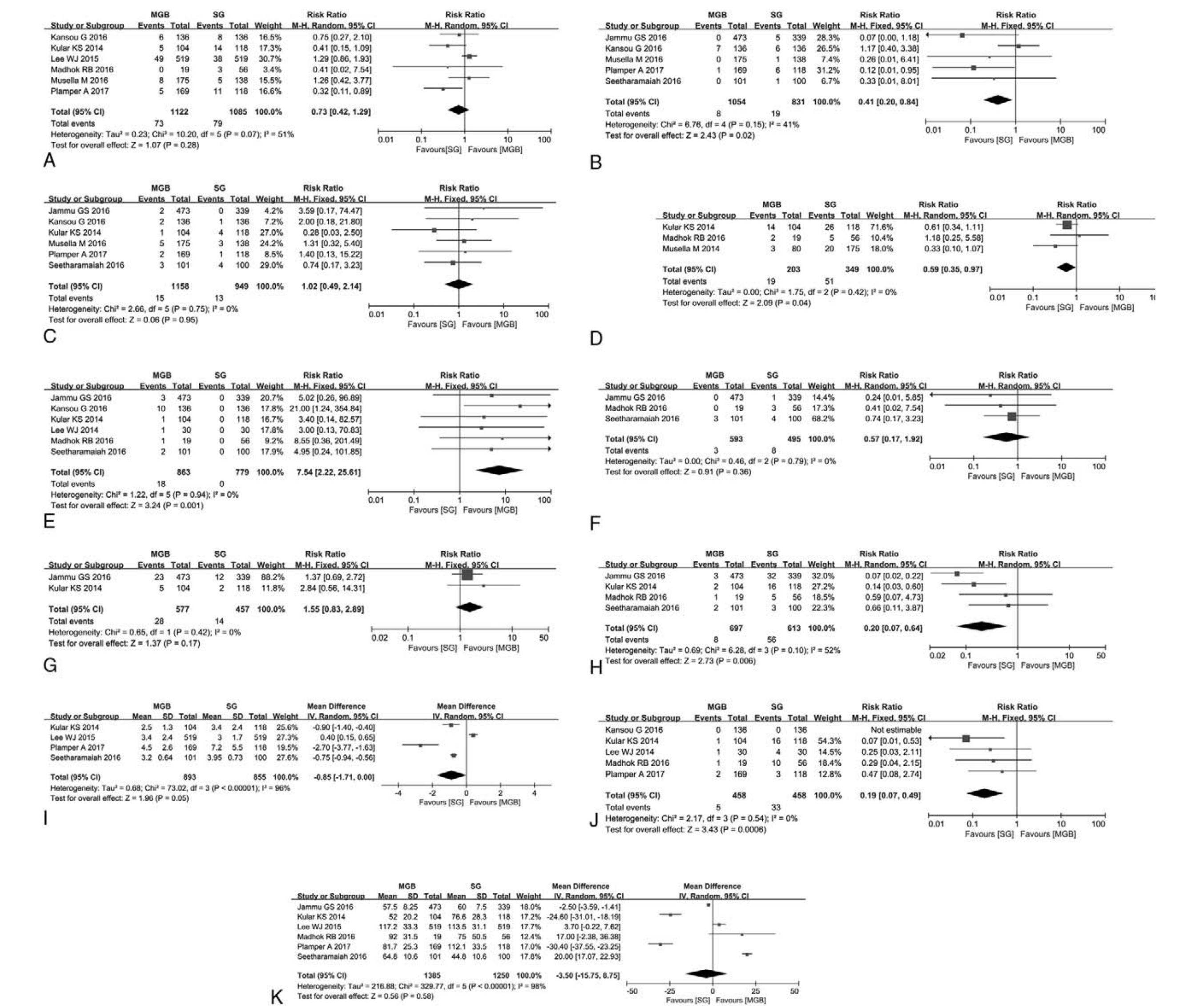

Figure 4. (A) Overall early complications rate of MGB versus SG. (B) Leakage rate of MGB versus SG. (C) Bleed rate of MGB versus SG. (D) Overall late complications rate of MGB versus SG. (E) Ulcer rate of MGB versus SG. (F) Vomiting rate of MGB versus SG. (G) Anemia rate of MGB versus SG. (H) GERD rate of MGB versus SG. (i) Hospital stay of MGB versus SG. (J) Revision rate of MGB versus SG. (K) Operation time of MGB versus SG. GERD = gastroesophageal reflux disease, MGB = mini-gastric bypass, SG = sleeve gastrectomy.

T2DM, hypertension, OSA and ostearthritis, respectively. Our results indicated MGB had a higher remission rate of T2DM, hypertension, OSA and a lower remission rate of ostearthritis than SG. The higher remission rate of comorbidities of MGB may be explained by foregut and hindgut hypothesis.[47,48] Due to the small sample size, the results on remission rate of OSA and ostearthritis may be unreliable. Future studies should include the endpoints of OSA and ostearthritis.

4.3. Early complications

The most common early complications include leakage, intraperitoneal bleed, wound infection, intraperitoneal abscess, and bowel obstruction. According to the results of our meta-analysis, the overall rate of early complications, leakage, and bleed of MGB were 6.5%, 0.76%, 1.3% versus 7.3%, 2.3%, 1.4% of SG. Rutledge et al[35] performed a retrospective and observational study on 2410 patients having MGB, results showed that the rate of early complications was 5.9% and rate of leakage was 1.08%. Noun et al[38] performed a similar study in 1000 consecutive patients, and results showed that the rate of early complications was 2.7% the rate of leakage was 0.43%, and the rate of bleeding was1.6%. Most recently, Taha et al[16] reported 1520 cases receiving MGB for consecutive 6 years, and results showed that the rate of early complications was 3.2% leakage rate was 0.1% and bleed rate was 1.7%. All the 3 large sample size observational studies presented the favorable rate early complications, which seemed superior than our results. Our results indicated MGB group had a similar overall rate early complications, similar bleed rate and lower leakage rate compared with SG group. The lower leakage rate in MGB group may be explained by the decreased intragastric pressures caused by pylorus exclusion.[42]

4.4. Late complications

The most common late complications include ulcer, stenosis, vomiting, anemia, bile reflux, GERD, and malnutrition. The overall rate of complications, ulcer, vomiting, anemia, and GERD were 9.4%, 2.1%, 0.51%, 4.9%, 1.1% for MGB versus 14.6%, 0%, 1.6%, 3.1%, 9.1% for SG. Previous large sample size and observational studies have reported the overall rate complications of 2% to 7.9%,[16,33,46] ulcer rate of 0.2% to 4%,[16,33–35,38,46] stenosis rate of 0.1% to 0.8%,[33,34,46] vomiting rate of,[34] anemia rate of 1.5% to 4.9%,[16,34,35] bile reflux rate of 0% to 1.6%,[16,33,38,46] GERD rate of 2%,[34] and malnutrition rate of 2%[34] for patients receiving MGB. Ulcer and stenosis generally happened at anastomosis area,[11,21,22,25,28,29] which may account for the higher ulcer rate in MGB patients, whereas no anastomosis existed in SG patients. The lower GERD rate may be due to decreased intragastric pressure in MGB patients, which has been proven by Tolone et al.[49] The authors hypothesized that the long narrow sleeve gastric tube could have caused an increase in intragastric pressure, triggering a rise in GERD. Bile reflux is the most concerned factor that limits the extension of MGB. Although previous observational studies reported a considerable rate of bile reflux (0%–1.6%), comparative studies on bile reflux between MGB and SG are rare. Tolone et al[49] performed a small sample size comparative study between MGB and SG, and concluded patients receiving MGB had significantly diminished total number of reflux episodes, including acidic, weakly acidic, and weakly alkaline reflux. The reason why bile reflux symptom was rarely described in previous reports on MGB was that the bile can be neutralized by gastric acid secreted by remnant gastric before flowing to the gastrointestinal anastomosis, and the neutralized bile had less stimulation on gastric mucosa. Our results showed MGB group had a lower vomiting rate and higher anemia rate than SG group, and there was no significant statistical difference between two groups. Only one study reported stenosis rate, bile reflux rate, and malnutrition rate in MGB and SG patients, so we did not pool these endpoints. Future comparative studies between MGB and SG should include the endpoints of bile reflux and malnutrition.

4.5. Hospital stay, operation time, and revision rate

Our results shown MGB patients had a shorter hospital stay, lower revision rate, and similar operation time than SG patients. The shorter hospital stay may be explained by less trauma in MGB. The major causes of revision were malnutrition,[22] bile reflux[27,29] for MGB patients, whereas weight regain,[22] severe GERD[22,25,27] for SG patients.

4.6. Previous meta-analysis

To our knowledge, there were 2 meta-analyses comparing MGB with SG published online. Quan et al[50] performed a meta-analysis of MGB versus SG, and concluded MGB group had the same %EWL ($P = .51$) and 1-year postoperative BMI ($P = .38$), lower revision rate ($P = .004$) and higher remission rate of T2DM ($P = .004$) than SG group. Only 6 studies were included in Quan, Y's meta-analysis, so the results were unreliable. Most recently, Magouliotis et al[51] performed a simple meta-analysis of MGB versus SG, wherein 10 English studies were included and most results (one-year EWL%, remission rate of T2DM, remission rate of hypertension, bleed rate, anemia rate, GERD rate, hospital stay, operation time, and revision rate) were similar to our meta-analysis. In our meta-analysis, MGB group had a higher remission rate of OSA and lower leakage rate than SG group ($P = .03$), which was different from the Magouliotis meta-analysis results. There were 3 main differences between our meta-analysis and the Magouliotis meta-analysis. First, there were more eligible studies and more patients included in our meta-analysis, which made our meta-analysis more reliable. Second, we pooled the additional endpoints of 5-year %EWL, remission rate of ostearthritis, overall rate of early complications, overall rate of late complications, ulcer rate, vomiting rate. Third, unlike the Magouliotis meta-analysis, the overlapped data were excluded from our meta-analysis. For example, data from the Milone[26] and Musella[13] study shared overlapped research time and their data were from the same hospital, and the data of the two studies were used by Magouliotis[26] to pool T2DM remission rate, while we excluded the earlier one.

4.7. Limitations

Our meta-analysis still had some limitations. First, only 2 of eligible studies were RCTs, the others were cohort studies with inherent selection bias. Second, small sample size and short follow-up time may influence the stability of result. Third, due to few eligible studies were included in our meta-analysis, so we did not perform an analysis of publication bias. Fourth, heterogeneity between studies was high in our meta-analysis, which may be explained by different basic patients' characteristics of included studies and different surgical level of different hospital.

5. Conclusions

MGB is a simple, safe, and effective bariatric procedure. Due to the biased data, small sample size and short follow-up time, our results may be unreliable. Large sample and multicenter RCT is needed to compare the effectiveness and safety between mini-gastric bypass and sleeve gastrectomy. Future study should also focus on the endpoints of bile reflux, remnant gastric cancer and long term effectiveness in MGB patients.

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