# **ORIGINAL CONTRIBUTIONS**





# A Comprehensive Comparison of LRYGB and LSG in Obese Patients Including the Effects on QoL, Comorbidities, Weight Loss, and Complications: a Systematic Review and Meta-Analysis

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# Abstract

**Purpose** To systematically and comprehensively evaluate the differences between laparoscopic Roux-en-Y gastric bypass (LRYGB) versus sleeve gastrectomy (LSG) in obese patients.

**Methods** A systematic literature search was performed in PubMed, EMBASE, Web of Science, and the Cochrane Library from inception to December 2018. The meta-analysis was performed by the RevMan 5.3 software.

**Results** Twenty-three articles with 7443 patients were included. In short term (<3 years), LRYGB was superior to LSG in terms of improving comorbidities (T2D, odds ratio (OR) 1.93, 1.06–3.52, P < 0.05, hypertension, OR 1.59, 1.08–2.34, P < 0.05, dyslipidemia, OR 1.61, 1.05–2.46, P < 0.05), but there were no differences in the midterm and long term. Quality of life (QoL) after bariatric surgery was included, but no differences were observed in the QoL after LRYGB or LSG (gastrointestinal quality of life index (GIQLI) and Moorehead–Ardelt quality of life questionnaire (M-A-Q), P > 0.05). LRYGB achieved a higher EWL% than LSG (after 3 years, WMD 5.48, 0.13–10.84. P < 0.05; after 5 years, WMD 4.55, 1.04–8.05, P < 0.05) in long term, but no significant differences were found during 0.25- to 2.0-year follow-up. The rate of early and late complications was much higher in LRYGB than in LSG (early complications, OR = 2.11, 95% CI = 1.53–2.91, P < 0.001; late complications, OR = 2.60, 95% CI = 1.93–3.49, P < 0.001).

**Conclusions** This meta-analysis showed that LRYGB was more effective than LSG in comorbidities' resolution or improvement in short term. For weight loss, LRYGB had better long-term effects than LSG. In addition, no differences were observed in the quality of life after LRYGB or LSG. LRYGB was associated with more complications than LSG.

Keywords Laparoscopic Roux-en-Y gastric bypass · Laparoscopic sleeve gastrectomy · Three-stage analysis · Obesity surgery

# Introduction

With its increasing prevalence, obesity has become a global public health problem over the past few decades [1]. Being

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Zhuoyin Wang 2944438919@qq.com overweight is accepted as a risk factor for serious health issues, such as type 2 diabetes, hypertension, diseases, or even cancers [2–4]. Compared with various strategies, including medications, behavior changes, and diet therapy, bariatric

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Department of Gastrointestinal Surgery, The First Affiliated Hospital of Zhengzhou University, NO.1 Jianshe East Road, Zhengzhou 450052, Henan, China surgery is still recognized as the most effective treatment for weight loss and improvements of the associated comorbidities [5–7].

Primary bariatric procedures include Roux-en-Y gastric bypass (RYGB), laparoscopic adjustable gastric banding (AGB), laparoscopic vertical banded gastroplasty (VBG), sleeve gastrectomy (SG), mini-gastric bypass/one anastomosis gastric bypass (MGB/OAGB), biliopancreatic diversion/duodenal switch (BPD/DS), and singleanastomosis duodeno-ileal bypass (SADI). Among these techniques, laparoscopic Roux-en-Y gastric bypass (LRYGB) and laparoscopic sleeve gastrectomy (LSG) have gained the most popularity. However, there is a sharp trend towards the utilization of LSG over the last decade and a decline in the use of LRYGB [8, 9]. Some studies suggest that LSG is easier and faster to perform and potentially safer compared with LRYGB [8, 10], while some indicate that LRYGB is more potent than LSG [11–13].

Some meta-analyses of LRYGB versus LSG have been performed before [14–17], but obvious shortcomings remain. Of the previous studies, some lack adequate stratified analysis with respect to EWL% and comorbidities [14, 15].

Here, we performed a comprehensive meta-analysis comparing LRYGB with LSG with respect to their early and late complications, and amount of weight loss at different time points after surgery, as well as the effect on comorbidities at three different terms (short term, midterm, and long term) and quality of life (presented by GIQLI and M-A-Q II).

# Materials and Methods

We performed a comprehensive literature search in PubMed, EMBASE, Web of Science, and the Cochrane Library from inception to December 2018. Our search strategy included the following key terms: laparoscopic sleeve gastrectomy, LSG, SG, LRYGB, RYGB, bariatric surgery, and obesity. The reference lists of potential articles as well as the extraction data were screened manually by two independent reviewers (Hu and Sun). Any data extraction inconsistency was assessed by a third reviewer (Li).

Inclusion criteria are as follows: (1) sample size of every group > 15 patients; (2) human study reported in English; (3) at least one of the following endpoints was included: early complications, resolution rate of comorbidities, and weight loss (performed as EWL%); (4) patient ages ranged from 18 to 70 years old; (5) comparative studies between LRYGB and LSG. Exclusion criteria are as follows: (1) non-human studies; (2) non-laparoscopic surgery; (3) studies that only included LRYGB or LSG; (4) case reports, analyses, comments, and overviews.

#### **Definition of Endpoints**

Early complications were defined as those occurring within 30 days after surgery, while late complications occurred over 30 days. For resolution or improvement rate of comorbidities, the definitions of different terms were as follows: short term (1 year after surgery), midterm (3 years), long term (5 years).

# **Data Extraction**

The following data were independently extracted from each eligible study: author, publication year, study design, sample size, overall rate of early and late complications, resolution/ improvement rate of comorbidities (T2DM, hypertension, OSA, dyslipidemia), and weight loss at every follow-up point. The extraction was completed by two reviewers (Hu and Sun).

#### **Statistical Analysis**

Review Manager for the Windows version 5.3 (The Nordic Cochrane Centre, Copenhagen, Denmark) was used for analysis. Weighted mean differences (WMD) with 95% confidence intervals (CI) were used to analyze continuous data, while odds ratios (ORs) with 95% CIs were used for the statistical analyses of dichotomous data. Heterogeneity was represented by I2 (low heterogeneity at values< 30%, moderate heterogeneity at values 30–50%, and high heterogeneity at values > 50%). The random-effects model was used for the analysis of studies with high heterogeneity, and the fixed-effects model was used for studies with low or moderate heterogeneity.

#### **Quality and Publication Bias Assessment**

The methodological quality of the included non-RCT studies was determined by the NOS (Newcastle–Ottawa scale). When the study scored  $\leq$  5, the study was assessed as low quality; when the study scored > 5, the study was assessed as high quality and was included in our meta-analysis. The methodological quality of the included RCTs was determined using Cochrane Collaboration's tool for risk of bias. Sensitivity analyses were performed by removing individual studies from the whole set of studies and analyzing the sources of significant heterogeneity. The exclusion of these studies did not influence the results. The funnel plot was used to measure publication bias. The shape of the funnel plot did not reveal obvious asymmetry (not shown).

# Results

The PRISMA flow diagram of our literature search is shown in Fig. 1. A total of 742 articles were identified from the

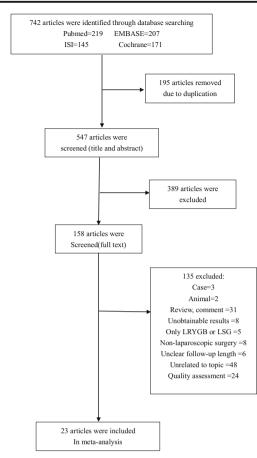


Fig. 1 PRISMA flow diagram

Fig. 2 Complications after

surgery

database, of which 719 studies were excluded after duplication, text screening, and discussion. Finally, 23 articles [18–40] were included in our analysis; 9 of them are RCTs, 5 of them are prospective studies, and 9 of them are retrospective studies. In addition, three articles [30-32] were from the same RCT but were published at different times, as well as another two articles [34, 39]. Therefore, we combined them together in the following tables. The risk of bias for the RCTs is presented in Fig. S1. The characteristics of the included studies are shown in Table. S1.

#### Complications

A total of 13 studies [18–20, 22, 24, 26, 27, 30, 33, 35, 37, 39, 40] reported early complications within 30 days, of which 5 studies [18, 20, 22, 26, 34] reported late complications. Overall, early complications occurred significantly more often after LRYGB than after LSG (OR = 2.11, 95% CI = 1.53–2.91, P < 0.001). As the definitions of major or minor complications were not consistent between studies, we did not perform the analysis of major and minor complications separately. Besides, LRYGB was also associated with more late complications than LSG (OR = 2.60, 95% CI = 1.93–3.49, P < 0.001).

All of the above data are shown in Fig. 2.

# Weight Loss Outcomes (EWL%)

Most outcomes of weight loss are measured by EWL%  $\pm$  SD, and we extracted data in our studies at 6 time points after surgery, including 3 months, 6 months, 1 year, 2 years, 3 years, and 5 years. There was high heterogeneity from 3 months to 3 years, and a random-effects model was applied to the analyses.

early overall complicatio		177 Contractor 1	LSC			Odds Ratio			Ratio	
Study or Subgroup	Events	Total	Events	Total	Weight	M-H, Random, 95% Cl	_	M-H, Rand	om, 95% Cl	
Albeladi, Bandar 2013	9	36	3	34	4.1%	3.44 [0.85, 14.04]			•	-
Benaiges 2011	16	95	4	45	5.4%	2.08 [0.65, 6.61]		-		
Boza 2011	56	786	24	811	12.5%	2.52 [1.54, 4.10]				•
Chouillard 2011	41	200	13	200	10.1%	3.71 [1.92, 7.17]				
Dogan 2015	14	245	19	245	9.4%	0.72 [0.35, 1.47]		· · ·	-	
El Chaar 2015	8	547	2	338	3.5%	2.49 [0.53, 11.81]		. <del>.</del>	1.1	
Helmiö, Mika 2014&2018	31	119	16	121	10.0%	2.31 [1.19, 4.50]			· · · · ·	-
Kehagias 2011	3	30	2	30	2.6%	1.56 [0.24, 10.05]	1 3-			_
Lee, W. J 2015	48	519	38	519	13.1%	1.29 [0.83, 2.01]		-	· · ·	
Peterli, R 2013/2017/2018	19	110	9	107	8.0%	2.27 [0.98, 5.28]			•	_
Rondelli 2016	35	301	11	280	9.6%	3.22 [1.60, 6.47]				
Vidal 2013	37	135	10	114	9.0%	3.93 [1.85, 8.32]				-
Zhang Y 2014	2	32	4	32	2.8%	0.47 [0.08, 2.75]				
Total (95% CI)		3155		2876	100.0%	2.11 [1.53, 2.91]			-	
Total events	319		155							
Heterogeneity: Tau <sup>2</sup> = 0.16;	Chi <sup>2</sup> = 24.	22, df =	12(P = 0)	0.02); I <sup>2</sup>	= 50%			1		-
Test for overall effect: Z = 4.5	52 (P < 0.0	00001)	0028-0				0.2	0.5 Favours LSG	Favours LRYGB	0
late complications	LRY	BB	LS	G		Odds Ratio		Odds	Ratio	
Study or Subgroup	Events	Total	Events	Total	Weight	M-H, Fixed, 95% Cl		M-H, Fixe	d, 95% Cl	
Albeladi, Bandar 2013	11	36	7	34	8.5%	1.70 [0.57, 5.06]				
Boza 2011	96	786	27	811	39.7%					
Dogan 2015	23	245	12	245				)		
Helmiö, Mika 2014&2018	31	119			28.7%			22 <del>.</del>		
Kehagias 2011	3	30			4.6%					
Total (95% CI)		1216		1241	100.0%	2.60 [1.93, 3.49]			•	
Total events	164		72			S 3 30				
Heterogeneity: Chi <sup>2</sup> = 9.27,	df = 4 (P)	= 0.05)	1= 57%				0.01	0.1	10	1
neterogeneity. Crit = 3.27,										

As shown in Fig. 3, there was no significant difference in the short term (from 3 months to 2 years) after surgery (P > 0.05). In contrast, in the midterm (after 3 years) and long term (after 5 years), LRYGB achieved a superior EWL% compared with LSG (P < 0.01).

ig. 3 EWL% after 3 months,	after 3 months Study or Subgroup	l Mean	RYGB SD	Total	Mean	LSG SD	Total	Weight	Mean Difference IV, Random, 95% Cl		Mean Differenc IV, Random, 95%	
months, 1 year, 2 years, 3 years,	Benaiges 2011		11.9	95		14.2	45	29.7%	-7.70 [-12.49, -2.91]	-		
nd 5 years	El Chaar 2015	47.39		441		10.95	259	37.3%	2.72 [1.05, 4.39]			-
liu 5 years	Helmiö, Mika 2014&2018		13.3	111	38.4	14.8	119	33.0%	3.00 [-0.63, 6.63]			-
	T-1-1/054/ 00						100	100.01				
	Total (95% CI) Heterogeneity: Tau <sup>2</sup> = 19.	83° Chi² =	1670	647 df = 2	(P = 0.0	002) 12 :		100.0%	-0.29 [-5.71, 5.14]			1 1
	Test for overall effect Z =				0 - 0.0	001/,1	00.0				-10 -5 0 Favours LSG Favou	5 10
	after 6 months	i	RYGB			LSG			Mean Difference		Mean Difference	
	Study or Subgroup	Mean	SD	Total	Mean		Total	Weight	IV, Random, 95% Cl	Č	IV, Random, 95%	
	Albeladi, Bandar 2013	55.9					34				20 T	
	Benaiges 2011	68.5					45	15.3%				
	Cutolo 2012 Du X 2016	44 62.4	13				15 63	12.5%				
	El Chaar 2015	64.67	14.41				259	17.6%			-	-
	Helmiö, Mika 2014&2018						119	0.0%				
	Nickel 2016 Perrone, F 2017	31.3 43.5					18	7.2%				
	renone, r 2017	40.0	0.4	142	. 46.4	6.1	162	17.3%	-3.30 [-3.31, -2.43]	2	10 A	
	Total (95% CI)			829			596	100.0%	1.46 [-4.15, 7.08]	<u>е</u> "	-	Sa - 6
	Heterogeneity: Tau <sup>2</sup> = 45.4			df = 6 (	P < 0.00	0001); I <sup>z</sup>	= 93%				20 -10 0	10 20
	Test for overall effect: Z = I	0.51 (P =	0.61)								Favours LSG Favou	ITS LRYGB
	after 1 year		YGB			SG			Mean Difference		Mean Differenc	
	Study or Subgroup	Mean		Total					IV, Random, 95% CI		IV, Random, 95%	CI
	Albeladi, Bandar 2013 Benaiges 2011	72.3 80.9	19 16.7	35 95	56.5 82.7	19.7 18	33 45	8.9% 9.9%	15.80 [6.59, 25.01] -1.80 [-8.04, 4.44]		+	
	Boza 2011		24.3	395	86.4	26.4	305	10.5%	10.80 [6.99, 14.61]		-	
	Cutolo 2012	60	17	16	54	15	15	8.1%	6.00 [-5.27, 17.27]			
	Dogan 2015		19.8	245	76.5	23.4		10.5%	-5.70 [-9.54, -1.86]		*	
	Du X 2016 El Chaar 2015		10.6	63 451	76.7	12.9 17.98	63 260	10.4%	3.40 [-0.72, 7.52] 11.09 [8.44, 13.74]		-	
	Ignat 2016		19.4	44	83	14	48	9.6%	-2.60 [-9.57, 4.37]			
	Perrone, F 2017	55.82	5.7		62.47	5.9	162	10.8%	-6.65 [-7.96, -5.34]			
	Rondelli 2016	61.5	21.8	282	49	13.4	259	10.6%	12.50 [9.48, 15.52]		*	
	Total (95% CI)		- 3	1768		8	1435	100.0%	4.14 [-2.24, 10.52]			
	Heterogeneity: Tau <sup>2</sup> = 97.	34' Chi <sup>2</sup> =			9 (P < 0				4.14 [-2.24, 10.32]			
	Test for overall effect: Z =			0, 01 = 1	0 (i - 0			~		-100	-50 0 Favours LSG Favou	50 1
	- <b>A A</b> - <b>A</b>											
	after 2 years		YGB	Total		LSG SD	Leto]	Moight	Mean Difference		Mean Differenc	
	Study or Subgroup Albeladi, Bandar 2013	Mean 72.3	19	Total 35	56.5	19.7	33	Weight 8.9%	IV, Random, 95% CI 15.80 [6.59, 25.01]		IV, Random, 95%	CI
	Benaiges 2011	80.9	16.7	95	82.7	18	45	9.9%	-1.80 [-8.04, 4.44]		-	
	Boza 2011	97.2	24.3	395	86.4	26.4	305	10.5%	10.80 [6.99, 14.61]		-	
	Cutolo 2012	60	17	16	54	15	15	8.1%	6.00 [-5.27, 17.27]		_	
	Dogan 2015 Du X 2016	70.8 80.1	19.8 10.6	245 63	76.5 76.7	23.4 12.9	245 63	10.5%	-5.70 [-9.54, -1.86] 3.40 [-0.72, 7.52]			
	El Chaar 2015		6.24	451	64.1		260	10.7%	11.09 [8.44, 13.74]		-	
	Ignat 2016	80.4	19.4	44	83	14	48	9.6%	-2.60 [-9.57, 4.37]		+	
	Perrone, F 2017	55.82	5.7		62.47	5.9	162	10.8%	-6.65 [-7.96, -5.34]			
	Rondelli 2016	61.5	21.8	282	49	13.4	259	10.6%	12.50 [9.48, 15.52]		-	
	Total (95% CI)			1768			1435	100.0%	4.14 [-2.24, 10.52]		*	
	Heterogeneity: Tau <sup>2</sup> = 97.			9, df =	9 (P < 0	.00001)	1² = 97	%		-100	-50 0	50 1
	Test for overall effect Z =	1.27 (P =	0.20)								Favours LSG Favou	
	after 3 years LRYGB LSG Mean Difference Mean Difference											3
				tal Me	1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1	AND 43	V.D. 1100		, Random, 95% Cl		IV, Random, 95%	CI
					6.8 27				6.30 [-1.11, 13.71]			
		69.7 25			9.7 25			.1%	0.00 [-6.26, 6.26]			
	Du X 2016 Ignat 2016	76.5 9 83 14			6.3 26				0.80 [7.29, 14.31] 6.70 [5.33, 28.07]		-	
		68.4 4		42 69		.1 16			1.54 [-2.63, -0.45]		-	
		61.7 20			1.1 17			.5%	0.60 [-3.95, 5.15]			
	Yang 2015	92.3 10	.5	27 8	1.9	14 2	8 13	.9% 1	0.40 [3.87, 16.93]			
	Total (95% CI)		6	99		64	5 100	0.016	5 40 10 13 40 041			
	Heterogeneity: Tau <sup>2</sup> = 42	75 Chi			6 (P < 1				5.48 [0.13, 10.84]			_
	Test for overall effect: Z =										-10 -5 0 5	10
						1.00			Mana Difference		Favours LSG Favour	
	after 5 years Study or Subgroup	Mear	LRYGB		Mean	LSG	Total	Weight	Mean Difference IV, Random, 95% Cl		Mean Differenc IV, Random, 95%	
	Dogan 2015		23.2			23.8	27	5.6%	2.60 [-11.16, 16.36]		10, 10, 10, 35 /	
	Helmiö, Mika 2014&2018		17.7	98		19.9	95	21.1%	8.00 [2.68, 13.32]		— —	
	Ignat 2016	74.8				22.6	41	8.7%	9.70 [-0.85, 20.25]		1	
	Lee, W. J 2015		24.2			30.3	116	17.4%	0.90 [-5.48, 7.28]			-
		72.34			70.26		161	40.5%	2.08 [1.53, 2.63]			
	Perrone, F 2017 Zhang Y 2014	76 3	217									
	Perrone, F 2017 Zhang Y 2014	76.2	21.7	28	63.2	24.5	26	6.7%	13.00 (0.62, 25.38)			
	Zhang Y 2014 Total (95% CI)			536			466	0.7% 100.0%	4.55 [1.04, 8.05]	3	-	•
	Zhang Y 2014	1; Chi² =	9.77, di	536			466			-120	-10 0 Favours LSG Favou	10

# Resolution/Improvement of Obesity-Related Comorbidities

Several studies have researched the resolution/improvement rate of comorbidities. Considering that the rates of the comorbidities may differ at different times after surgery, we performed a meta-analysis at three different times.

#### Short-Term Obesity-Related Comorbidities

There was no remarkable heterogeneity in any of the comorbidities (P > 0.05), so fixed-effects models were used. Except for sleep apnea, we found that the resolution/improvement rate of T2D, hypertension, and dyslipidemia all showed significant differences between LRYGB and LSG (Fig. 4). In addition, LRYGB achieved a superior rate of resolution/

Fig. 4 Short-term resolution/ improvement rate

improvement for T2D, hypertension, and dyslipidemia compared with LSG.

#### Midterm Obesity-Related Comorbidities

As shown in (Fig. 5), there were no significant differences in any of the comorbidities mentioned.

#### Long-Term Obesity-Related Comorbidities

LRYGB achieved a better long-term (> 5 years) prognosis for hypertension after surgery than LSG with a significant difference (Fig. 6) (OR = 1.98, 95% CI = 1.13-3.48, P < 0.05). The other comorbidities showed no differences between the two procedures.

T2D	LRYC		LSO			Odds Ratio	Odds Ratio M-H, Fixed, 95% Cl						
Study or Subgroup						M-H, Fixed, 95% Cl		M-H, Fixed, 95% Cl					
Albeladi, Bandar 2013	6	7		1					_				
Chouillard 2011	45	52		29				71					
Cutolo 2012	14	15		15									
Du X 2016	17	21	11	16									
Gill 2016	17	23		20									
Helmiö, Mika 2014&2018	40	43	48	50	20.4%	0.56 [0.09, 3.49]							
Vidal 2013	36	39	23	24	14.4%	0.52 [0.05, 5.32]		5. C					
Total (95% CI)		200		155	100.0%	1.93 [1.06, 3.52]		•					
Total events	175		125										
Heterogeneity: Chi2 = 4.71	, df = 6 (P =	= 0.58)	<sup>2</sup> = 0%				0.01	0,1 1 10	100				
Test for overall effect: Z = 3	2.16 (P = 0.	.03)					0.01	Favours LSG Favours LRYGB	100				
hypertension	LRYC	B	LS	3		Odds Ratio		Odds Ratio					
Study or Subgroup					Weight	M-H, Fixed, 95% Cl		M-H, Fixed, 95% Cl					
Albeladi, Bandar 2013	7	15		13					_				
Benaiges 2011	39	43		14	2 070701								
Chouillard 2011	28	43		34		2 An extension of a second s							
	20	43		9		영수는 지 같은 것 같은 것이 생각하는 것이 같은 것이 같이 했다.			_				
Cutolo 2012	9	16			9 1000100								
Du X 2016				17									
Gill 2016	16	33		34									
Helmiö, Mika 2014&2018		87	100	83									
Vidal 2013	36	50	27	38	21.2%	1.05 [0.41, 2.67]							
Total (95% CI)	12500	296	1246	242	100.0%	1.59 [1.08, 2.34]		<b>•</b>					
Total events	214	Sestimation	147										
Heterogeneity: Chi <sup>2</sup> = 7.00 Test for overall effect: Z =			, l <sup>2</sup> = 0%				0.01	0.1 1 10 Favours LSG Favours LRYGB	100				
dyslipidemia	LRYG	B	LSG	6		Odds Ratio		Odds Ratio					
Study or Subgroup	Events	Total	Events	Total	Weight	M-H, Fixed, 95% C	l	M-H, Fixed, 95% Cl					
Benaiges 2011	22	22	9	12	0.8%	16.58 [0.78, 353.12	1	-					
Cutolo 2012	1	2	3	5	2.6%	0.67 [0.02, 18.06							
Du X 2016	21	33	21	36	21.8%	1.25 [0.47, 3.30	1						
Gill 2016	23	32	16	30	13.9%	2.24 [0.78, 6.41	ì						
Helmiö, Mika 2014&2018	31	45	25	39	24.8%	1.24 [0.50, 3.08	1						
Vidal 2013	54	79	33	57	36.2%								
Total (95% CI)		213		179	100.0%	1.61 [1.05, 2.46]	1	•					
Total events	152		107										
Heterogeneity: Chi# = 3.46	, df = 5 (P =	0.63);	I <sup>2</sup> = 0%				to at		100				
Test for overall effect: Z = 2							0.01	0.1 1 10 Favours LSG Favours LRYGB	100				
sleep apnea	LRYGB		LSG			Odds Ratio		Odds Ratio					
Study or Subgroup	Events T	otal E	Events	Total	Weight	M-H, Fixed, 95% Cl		M-H, Fixed, 95% Cl					
Albeladi, Bandar 2013	13	13	7	9	3.6%	The second s							
Chouillard 2011	32	36	36	41	43.6%	1.11 [0.27, 4.50]							
Du X 2016	10	15	12	20	39.9%	1.33 [0.33, 5.39]							
Vidal 2013	26	27	38	42	12.8%	2.74 [0.29, 25.90]							
Total (95% CI)		91		112	100.0%	1.70 [0.73, 3.94]							
	01	31	93	112	100.0%	1.10 [0.13, 3.94]							
Total events	81												
Heterogeneity: Chi <sup>2</sup> = 1.7 Test for overall effect: Z =			); (* = 0%				0.01	0.1 1 10 Favours LSG Favours LRYGB	100				

Fig. 6 Long-term resolution/

improvement rate

T2D Study or Subgroup	LRYG Events	10.0	LS0 Events		Weight	Odds Ratio M-H, Fixed, 95% Cl		Odds Ratio M-H, Fixed, 95% Cl	
Boza 2011	37	43	29	32	35.7%	0.64 [0.15, 2.77]			
Du X 2016	12	19	8	14	26.1%	1.29 [0.31, 5.27]			
Helmiö, Mika 2012&2018	40	42	43	46	15.0%	1.40 [0.22, 8.79]			
Kehagias 2011	4	5	4	5	6.1%	1.00 [0.05, 22.18]			
Peterli, R 2013/2017/2018	28	28	25	26	3.5%	3.35 [0.13, 86.03]			
Yang 2015	28	30	27	31	13.6%	2.07 [0.35, 12.27]			
Total (95% CI)	100	167		154	100.0%	1.23 [0.59, 2.56]		-	
Total events	149		136						
Heterogeneity: Chi <sup>2</sup> = 1.51, c Test for overall effect: Z = 0.5			*= 0%				0.01	0.1 1 10 1	
								Favours LSG Favours LRYGB	
hypertension Study or Subgroup	LRYG		LSG Events		Woight	Odds Ratio M-H, Fixed, 95% Cl		Odds Ratio M-H, Fixed, 95% Cl	
Boza 2011	123	217	110	190	87.0%	0.95 [0.64, 1.41]			
Du X 2016	5	14	4	16	4.1%	1.67 [0.35, 8.04]		— <del>—</del> ——	
<ehagias 2011<="" td=""><td>3</td><td>5</td><td>3</td><td>4</td><td>2.3%</td><td>0.50 [0.03, 8.95]</td><td><u> </u></td><td></td></ehagias>	3	5	3	4	2.3%	0.50 [0.03, 8.95]	<u> </u>		
Peterli, R 2013/2017/2018	63	65	67	67	4.3%	0.19 [0.01, 4.00]	•		
rang 2015	9	12	5	10	2.3%	3.00 (0.50, 18.17)			
Total (95% CI)		313		287	100.0%	0.99 [0.68, 1.42]		<b>•</b>	
Fotal events	203	313	189	2.01	100.070	0.00 [0.00, 1.42]		T	
Heterogeneity: Chi# = 3.27, c		0.51): P					L		
Test for overall effect: Z = 0.0			11111111				0.01	0.1 1 10 1 Favours LSG Favours LRYGB	
velinidamia	LRYG	B	LSG			Odds Ratio		Odds Ratio	
lyslipidemia Study or Subgroup	Events		Events		Weight	M-H, Fixed, 95% Cl		M-H, Fixed, 95% Cl	
Boza 2011	141	320	142	340	87.2%	1.10 [0.81, 1.50]			
Du X 2016	17	33	18	32	10.0%	0.83 [0.31, 2.19]			
Kehagias 2011	9	10	6	8	0.8%	3.00 [0.22, 40.93]			
Peterli, R 2013/2017/2018	55	56	57	72	1.0%	14.47 [1.85, 113.32]			
Yang 2015	17	18	18	21	1.0%	2.83 [0.27, 29.96]			
Total (95% CN		137		472	100.0%	12410.04 464			
Total (95% CI) Total events	239	437	241	4/3	100.0%	1.24 [0.94, 1.64]		L.	
rotal events Heterogeneity: Chi <sup>2</sup> = 7.64, d		0 1 1 \					<u> </u>	I I I	
Test for overall effect: Z = 1.5			- 40 /0				0.01	0.1 1 10 1 Favours LSG Favours LRYGB	
720	1 PVG	R	150			Odde Patio		Odde Patio	
	LRYG Events	Total	LSG Events	Total		Odds Ratio M-H, Fixed, 95% CI		Odds Ratio M-H, Fixed, 95% Cl	
Study or Subgroup Helmiö, Mika 2014&2018	Events 38	Total 40	Events 36	Total 41	19.2%	M-H, Fixed, 95% Cl 2.64 [0.48, 14.47]			
Study or Subgroup Helmiö, Mika 2014&2018 Perrone, F 2017	Events	Total	Events	Total		M-H, Fixed, 95% Cl			
Study or Subgroup Helmiö, Mika 2014&2018 Perrone, F 2017 Peterli, R 2013/2017/2018	Events 38 17	Total 40 20	Events 36 6	<u>Total</u> 41 7	19.2% 14.4%	M-H, Fixed, 95% Cl 2.64 [0.48, 14.47] 0.94 [0.08, 10.91]			
Study or Subgroup Helmiö, Mika 2014&2018 Perone, F 2017 Peterli, R 2013/2017/2018 Zhang Y 2014	Events 38 17 21	Total 40 20 28	Events 36 6 20	Total 41 7 26 9	19.2% 14.4% 56.1%	M-H, Fixed, 95% CI 2.64 [0.48, 14.47] 0.94 [0.08, 10.91] 0.90 [0.26, 3.14] 0.88 [0.05, 16.74]			
Study or Subgroup Helmiö, Mika 2014&2018 Perrone, F 2017 Peterli, R 2013/2017/2018	Events 38 17 21	Total 40 20 28 8	Events 36 6 20	Total 41 7 26 9	19.2% 14.4% 56.1% 10.2%	M-H, Fixed, 95% Cl 2.64 [0.48, 14.47] 0.94 [0.08, 10.91] 0.90 [0.26, 3.14]	1		
Study or Subgroup Helmio, Mika 2014&2018 Perrone, F 2017 Peterli, R 2013/2017/2018 Zhang Y 2014 Fotal (95% CI) Total events Heterogeneity: Chi <sup>2</sup> = 1.11, c	Events 38 17 21 7 83 # = 3 (P =	Total 40 20 28 8 96 0.77); F	Events 36 20 8 70	Total 41 7 26 9	19.2% 14.4% 56.1% 10.2%	M-H, Fixed, 95% CI 2.64 [0.48, 14.47] 0.94 [0.08, 10.91] 0.90 [0.26, 3.14] 0.88 [0.05, 16.74]	L 0.01	M-H, Fixed, 95% Cl	
Study or Subgroup Helmio, Mika 2014&2018 Perrone, F 2017 Peterli, R 2013/2017/2018 Zhang Y 2014 Fotal (95% CI) Fotal events Heterogeneity: Chi <sup>2</sup> = 1.11, c Fest for overall effect Z = 0.4	Events 38 17 21 7 83 df = 3 (P = 49 (P = 0.6	Total 40 20 28 8 96 0.77); F 3)	Events 36 20 8 70 *= 0%	Total 41 7 26 9 83	19.2% 14.4% 56.1% 10.2%	M.H. Fixed, 95% CI 2.64 [0.48, 14.47] 0.94 [0.08, 10.91] 0.90 [0.26, 3.14] 0.88 [0.05, 16.74] 1.24 [0.52, 2.94]	H 0.01	M-H, Fixed, 95% CI	
Study or Subgroup Helmio, Mika 2014&2018 Perrone, F 2017 Peterli, R 2013/2017/2018 Zhang Y 2014 Fotal (95% CI) Fotal events Heterogeneity: Chi <sup>2</sup> = 1.11, c Fest for overall effect: Z = 0.4 hypertension	Events 38 17 21 7 83 df = 3 (P = 19 (P = 0.6 LRYG	Total 40 20 28 8 96 0.77); F 3) B	Events 36 6 20 8 70 *=0% LSG	Total 41 7 26 9 83	19.2% 14.4% 56.1% 10.2%	M.H, Fixed, 95% CI 2.64 [0.48, 14.47] 0.94 [0.08, 10.91] 0.90 [0.26, 3.14] 0.88 [0.05, 16.74] 1.24 [0.52, 2.94] Odds Ratio	L	M-H, Fixed, 95% Cl 0.1 10 1 Favours LSG Favours LRYGB Odds Ratio	
Study or Subgroup Helmio, Mika 2014&2018 Perrone, F 2017 Peterli, R 2013/2017/2018 Zhang Y 2014 Fotal (95% CI) Total events Heterogeneity: Chi <sup>2</sup> = 1.11, c Fest for overall effect: Z = 0.4 hypertension Study or Subgroup	Events 38 17 21 7 83 df = 3 (P = 49 (P = 0.6	Total 40 20 28 8 96 0.77); F 3) B	Events 36 20 8 70 *= 0%	Total 41 7 26 9 83	19.2% 14.4% 56.1% 10.2%	M.H. Fixed, 95% CI 2.64 [0.48, 14.47] 0.94 [0.08, 10.91] 0.90 [0.26, 3.14] 0.88 [0.05, 16.74] 1.24 [0.52, 2.94] Odds Ratio M.H. Fixed, 95% CI	L 0.01	M-H, Fixed, 95% CI	
Study or Subgroup Helmio, Mika 2014&2018 Perrone, F 2017 Peterli, R 2013/2017/2018 Zhang Y 2014 Total (95% CI) Fotal events Heterogeneity: Chi <sup>2</sup> = 1.11, o Fest for overall effect: Z = 0.4 hypertension Study or Subgroup Helmiö, Mika 2014&2018	Events 38 17 21 7 83 ff = 3 (P = 19 (P = 0.6 LRYG Events	Total 40 20 28 8 96 0.77); F 3) B Total	Events 36 6 20 8 70 *= 0% LSG Events	Total 41 7 26 9 83 83	19.2% 14.4% 56.1% 10.2% 100.0%	M.H, Fixed, 95% CI 2.64 [0.48, 14.47] 0.94 [0.08, 10.91] 0.90 [0.26, 3.14] 0.88 [0.05, 16.74] 1.24 [0.52, 2.94] Odds Ratio	6.01	M-H, Fixed, 95% Cl 0.1 10 1 Favours LSG Favours LRYGB Odds Ratio	
Study or Subgroup Helmio, Mika 2014&2018 Perrone, F 2017 Peterli, R 2013/2017/2018 Zhang Y 2014 fotal (95% CI) Fotal events Heterogeneity: Chi <sup>2</sup> = 1.11, o Fest for overall effect: Z = 0.4 hypertension Study or Subgroup Helmiö, Mika 2014&2018 Perrone, F 2017	Events 38 17 21 7 83 3f = 3 (P = 19 (P = 0.6 Events 59 19 59	Total 40 20 28 8 96 0.77); F 3) B Total 73 25 64	Events 36 6 20 8 70 *= 0% LSO Events 44 11 56	Total 41 7 26 9 83 83 5 5 5 68 17 64	19.2% 14.4% 56.1% 10.2% 100.0% Weight 50.4%	<u>M.H. Fixed, 95% C1</u> 2.64 [0.48, 14.47] 0.94 [0.08, 10.91] 0.90 [0.26, 3.14] 0.88 [0.05, 16.74] <b>1.24 [0.52, 2.94]</b> Odds Ratio <u>M.H. Fixed, 95% C1</u> 2.30 [1.07, 4.95]	0.01	M-H, Fixed, 95% Cl 0.1 10 1 Favours LSG Favours LRYGB Odds Ratio	
Study or Subgroup           Helmio, Mika 2014 & 2018           Perrone, F 2017           Peterli, R 2013/2017/2018           Zhang Y 2014           fotal (95% CI)           Fotal events           Heterogeneity: Chi <sup>2</sup> = 1.11, c           Fest for overall effect: Z = 0.4           hypertension           Study or Subgroup           Helmio, Mika 2014&2018           Perrone, F 2017           Peterli, R 2013/2017/2018	Events 38 17 21 7 83 1f = 3 (P = 19 (P = 0.6 LRYG Events 59 19	Total 40 20 28 8 96 0.77); F 3) B Total 73 25	Events 36 6 20 8 70 *= 0% LSG Events 44 11	Total 41 7 26 9 83 83 <u>83</u> 58 68 17	19.2% 14.4% 56.1% 10.2% 100.0% Weight 50.4% 18.1%	<u>M.H. Fixed, 95% CI</u> 2.64 [0.48, 14.47] 0.94 [0.08, 10.91] 0.90 [0.26, 3.14] 0.88 [0.05, 16.74] 1.24 [0.52, 2.94] Odds Ratio <u>M.H. Fixed, 95% CI</u> 2.30 [1.07, 4.95] 1.73 [0.45, 6.69]	0.01	M-H, Fixed, 95% Cl 0.1 10 1 Favours LSG Favours LRYGB Odds Ratio	
Study or Subgroup           Helmio, Mika 2014 & 2018           Perrone, F 2017           Perrone, F 2013/2017/2018           Chang Y 2014           Fotal (95% CI)           Fotal events           Heterogeneity: Chi <sup>2</sup> = 1.11, c           Fest for overall effect: Z = 0.4           hypertension           Study or Subgroup           Helmio, Mika 2014&2018           Perrone, F 2017           Peterii, R 2013/2017/2018           Zhang Y 2014	Events 38 17 21 7 83 3f = 3 (P = 19 (P = 0.6 Events 59 19 59	Total 40 20 28 8 96 0.77); F 3) B Total 73 25 64	Events 36 6 20 8 70 *= 0% LSO Events 44 11 56	Total 41 7 26 9 83 83 <u>Total</u> 68 17 64 5	19.2% 14.4% 56.1% 10.2% 100.0% Weight 50.4% 18.1% 25.2% 6.3%	M.H. Fixed, 95% CI 2.64 [0.48, 14.47] 0.94 [0.08, 10.91] 0.90 [0.26, 3.14] 1.88 [0.05, 16.74] 1.24 [0.52, 2.94] Odds Ratio M.H. Fixed, 95% CI 2.30 [1.07, 4.95] 1.73 [0.45, 6.69] 1.69 [0.52, 5.46] 1.33 [0.11, 15.70]	0.01	M-H, Fixed, 95% Cl 0.1 10 1 Favours LSG Favours LRYGB Odds Ratio	
Study or Subgroup           Helmio, Mika 2014 & 2018           Perrone, F 2017           Peterli, R 2013/2017/2018           Zhang Y 2014           Fotal (95% CI)           Fotal events           Heterogeneity: Chi <sup>2</sup> = 1.11, c           Fest for overall effect: Z = 0.4           hypertension           Study or Subgroup           Hetering, Mika 2014&2018           Perrone, F 2017           Peterli, R 2013/2017/2018           Chang Y 2014           Fotal (95% CI)           Fotal events	Events         38           38         17           21         7           31         7           35         9           36         LRYG           Events         59           59         59           59         59           4         141	Total 40 20 28 8 96 0.77); F 3) B Total 73 25 64 6 168	Events 36 6 20 8 70 <sup>≠</sup> =0% Events 44 11 56 3 114	Total 41 7 26 9 83 83 <u>Total</u> 68 17 64 5	19.2% 14.4% 56.1% 10.2% 100.0% Weight 50.4% 18.1% 25.2%	<u>M.H. Fixed, 95% CI</u> 2.64 [0.48, 14.47] 0.94 [0.08, 10.91] 0.90 [0.26, 3.14] 0.88 [0.05, 16.74] 1.24 [0.52, 2.94] Odds Ratio <u>M.H. Fixed, 95% CI</u> 2.30 [1.07, 4.95] 1.73 [0.45, 6.69] 1.69 [0.52, 5.46]	0.01	M-H, Fixed, 95% Cl 0.1 10 1 Favours LSG Favours LRYGB Odds Ratio	
Study or Subgroup           4elmio, Mika 2014&2018           Perrone, F 2017           Peterli, R 2013/2017/2018           Zhang Y 2014           Fotal (95% CI)           Fotal events           Heterogeneity: Chi² = 1.11, c           Fest for overall effect: Z = 0.4           hypertension           Study or Subgroup           4elmio, Mika 2014&2018           Perrone, F 2017           Peterli, R 2013/2017/2018           Zhang Y 2014           Fotal (95% CI)           Fotal (95% CI)           Fotal events           Heterogeneity: Chi² = 0.36, c	Events           38           17           21           7           83           if = 3 (P =           19 (P = 0.6           LRYG           59           19           59           4           141           if = 3 (P =	Total 40 20 28 8 96 0.77); F 3) B Total 73 25 64 6 168 0.95); F	Events 36 6 20 8 70 <sup>≠</sup> =0% Events 44 11 56 3 114	Total 41 7 26 9 83 83 <u>Total</u> 68 17 64 5	19.2% 14.4% 56.1% 10.2% 100.0% Weight 50.4% 18.1% 25.2% 6.3%	M.H. Fixed, 95% CI 2.64 [0.48, 14.47] 0.94 [0.08, 10.91] 0.90 [0.26, 3.14] 1.88 [0.05, 16.74] 1.24 [0.52, 2.94] Odds Ratio M.H. Fixed, 95% CI 2.30 [1.07, 4.95] 1.73 [0.45, 6.69] 1.69 [0.52, 5.46] 1.33 [0.11, 15.70]	0.01	M-H, Fixed, 95% Cl 0.1 10 1 Favours LSG Favours LRYGB Odds Ratio	
Study or Subgroup           4elmio, Mika 2014&2018           Perrone, F 2017           Peterli, R 2013/2017/2018           Zhang Y 2014           Fotal (95% CI)           Fotal events           Heterogeneity: Chi² = 1.11, c           Fest for overall effect: Z = 0.4           hypertension           Study or Subgroup           4elmio, Mika 2014&2018           Perrone, F 2017           Peterli, R 2013/2017/2018           Zhang Y 2014           Fotal (95% CI)           Fotal (95% CI)           Fotal events           Heterogeneity: Chi² = 0.36, c	Events           38           17           21           7           83           if = 3 (P =           19 (P = 0.6           LRYG           59           19           59           4           141           if = 3 (P =	Total 40 20 28 8 96 0.77); F 3) B Total 73 25 64 6 168 0.95); F	Events 36 6 20 8 70 <sup>≠</sup> =0% Events 44 11 56 3 114	Total 41 7 26 9 83 83 <u>Total</u> 68 17 64 5	19.2% 14.4% 56.1% 10.2% 100.0% Weight 50.4% 18.1% 25.2% 6.3%	M.H. Fixed, 95% CI 2.64 [0.48, 14.47] 0.94 [0.08, 10.91] 0.90 [0.26, 3.14] 1.88 [0.05, 16.74] 1.24 [0.52, 2.94] Odds Ratio M.H. Fixed, 95% CI 2.30 [1.07, 4.95] 1.73 [0.45, 6.69] 1.69 [0.52, 5.46] 1.33 [0.11, 15.70]		M-H, Fixed, 95% CI	
Study or Subgroup           Helmio, Mika 2014&2018           Helmio, Mika 2014&2018           Perrone, F. 2017           Peterli, R. 2013/2017/2018           Zhang, Y. 2014           fotal (95% CI)           Fotal events           Heterogeneity: Chi <sup>2</sup> = 1.11, c           Fest for overall effect: Z = 0.4           hypertension           Study or Subgroup           Helmio, Mika 2014&2018           Perrone, F. 2017           Peterini, R. 2013/2017/2018           Zhang, Y. 2014           Fotal events           Heterogeneity: Chi <sup>2</sup> = 0.36, c           Fest for overall effect: Z = 2.3           dyslipidemia	Events           38           17           21           7           83           if = 3 (P =           19 (P = 0.6           LRYG           59           19           59           19           59           19           59           19           59           19           59           19           59           19           59           19           59           19           59           19           59           19           59           19           59           19           59           19           59           19           59           19           59           138 (P = 0.0           LRYG	Total 40 20 28 8 96 0.77); F 73 33) B Total 6 168 0.95); F 168 0.95); F 8 168 168 168 168 168 168 168	Events         36         6         20         8         70         2         0%         2         0%         11         56         3         114         2         0%         LSG           114         2         0%         LSG         114         2         0%         LSG         0%	Total 41 7 26 9 83 83 68 17 64 5 154	19.2% 14.4% 56.1% 10.2% 100.0% <b>Weight</b> 50.4% 18.1% 25.2% 6.3% 100.0%	M.H. Fixed, 95% CI 2.64 [0.48, 14.47] 0.94 [0.08, 10.91] 0.90 [0.26, 3.14] 1.24 [0.52, 2.94] Odds Ratio M.H. Fixed, 95% CI 2.30 [1.07, 4.95] 1.73 [0.45, 6.69] 1.69 [0.52, 5.46] 1.33 [0.11, 15.70] 1.98 [1.13, 3.48] Odds Ratio		M-H, Fixed, 95% CI	
Study or Subgroup           Helmiö, Mika 2014&2018           Perrone, F 2017           Peterli, R 2013/2017/2018           Zhang, Y 2014           Fotal (95% CI)           Total events           Heterogeneity: Chi <sup>2</sup> = 1.11, c           Test for overall effect: Z = 0.4           hypertension           Study or Subgroup           Helmiö, Mika 2014&2018           Perrone, F 2017           Peterli, R 2013/2017/2018           Zhang, Y 2014           Total events           Heterogeneity: Chi <sup>2</sup> = 0.36, c           Test for overall effect: Z = 2.3           dyslipidemia           Study or Subgroup	Events           38           17           21           7           83           1f = 3 (P =           19 (P = 0.6           LRYG           Events           59           19           59           4           141           ff = 3 (P =           80 (P = 0.03)           LRYG           Events	Total         40           40         20           28         8           96         0.77); I'           Total         73           25         64           6         168           0.95); I'         122           B         Total           Total         122	Events         36         6         20         20         8         70         = 0%         LSG         Events         44         11         56         3         3         = 114         = 114         = 10%         LSG         Events         Events         Events         Events         20%         <	Total         41           7         26           9         83           Total         68           17         64           5         154           Total         5	19.2% 14.4% 56.1% 10.2% 100.0% ¥eight 00.0%	M.H. Fixed, 95% CI 2.64 [0.48, 14.47] 0.94 [0.08, 10.91] 0.90 [0.26, 3.14] 0.88 [0.05, 16.74] 1.24 [0.52, 2.94] 0.88 [0.05, 16.74] 1.24 [0.52, 2.94] 2.30 [1.07, 4.95] 1.73 [0.45, 6.69] 1.69 [0.52, 5.46] 1.33 [0.11, 15.70] 1.98 [1.13, 3.48] 0dds Ratio M.H. Fixed, 95% CI		M-H, Fixed, 95% CI	
Study or Subgroup           Helmio, Mika 2014&2018           Perrone, F 2017           Peterli, R 2013/2017/2018           Zhang Y 2014           fotal (95% CI)           Fotal events           Heterogeneity: Chi <sup>2</sup> = 1.11, c           Fest for overall effect: Z = 0.4           hypertension           Study or Subgroup           Helmiö, Mika 2014&2018           Perrone, F 2017           Peterli, R 2013/2017/2018           Chang Y 2014           Total events           Heterogeneity: Chi <sup>2</sup> = 0.36, c           Forst for overall effect: Z = 2.3           dyslipidemia           Study or Subgroup           Heterogeneity: Chi <sup>2</sup> = 0.36, c           Fest for overall effect: Z = 2.3           dyslipidemia           Study or Subgroup           Hetmio, Mika 2014&2018	Events           38           17           21           7           83           ff = 3 (P =           19 (P = 0.6           LRYG           Events           59           19           59           4           141           ff = 3 (P =           38 (P = 0.0           LRYG           Events           20	Total         40           40         20           28         8           96         0.77); I', I'           Total         73           B         Total           168         0.95); I'           B         Total           30         30	Events         36         6         20         20         8         70         2*         0%         LSG         Events         44         111         56         3         3         114         *         0%         LSG         Events         26         Events         26 <th26< th=""> <th20< th=""></th20<></th26<>	Total 41 7 26 9 83 83 17 64 5 154 154	19.2% 14.4% 56.1% 10.2% 100.0% Weight 50.4% 6.3% 100.0% Weight 56.0%	<u>M.H. Fixed, 95% CI</u> 2.64 [0.48, 14.47] 0.94 [0.08, 10.91] 0.90 [0.26, 3.14] 0.88 [0.05, 16.74] 1.24 [0.52, 2.94] 0dds Ratio <u>M.H. Fixed, 95% CI</u> 2.30 [1.07, 4.95] 1.69 [0.52, 5.46] 1.33 [0.11, 15.70] 1.98 [1.13, 3.48] 0dds Ratio <u>M.H. Fixed, 95% CI</u> 1.08 [0.40, 2.92]		M-H, Fixed, 95% CI	
Study or Subgroup Helmio, Mika 2014&2018 Perrone, F 2017 Peterli, R 2013/2017/2018 Zhang Y 2014 Fotal (95% CI) Fotal events Heterogeneity: Chi <sup>2</sup> = 1.11, c Fest for overall effect: Z = 0.4 hypertension Study or Subgroup Helmiö, Mika 2014&2018 Perrone, F 2017 Peterli, R 2013/2017/2018 Zhang Y 2014 Fotal (95% CI) Fotal events Heterogeneity: Chi <sup>2</sup> = 0.36, c Fest for overall effect: Z = 2.3 dyslipidemia Study or Subgroup Helmiö, Mika 2014&2018 Perrone, F 2017	Events           38           17           21           7           83           if = 3 (P =           19 (P = 0.6           LRYG           59           19           59           4           141           if = 3 (P =           38 (P = 0.0           LRYG           Events           20           4	Total         40           40         20           28         8           96         0.77); F           Total         73           25         64           6         6           168         0.95); F           B         Total           30         8           168         0.95); F           163         0.95); F	Events 36 6 20 8 70 *= 0% LSO Events 114 2 26 44 114 2 26	Total 41 7 26 9 83 83 10tal 68 17 64 5 154 154 154 7 7 0tal 7 7	19.2% 14.4% 56.1% 10.2% 100.0% Weight 50.4% 25.2% 6.3% 100.0%	<u>M.H. Fixed, 95% CI</u> 2.64 [0.48, 14.47] 0.94 [0.08, 10.91] 0.90 [0.26, 3.14] 0.88 [0.05, 16.74] <b>1.24 [0.52, 2.94]</b> Odds Ratio <u>M.H. Fixed, 95% CI</u> 2.30 [1.07, 4.95] 1.73 [0.45, 6.69] 1.69 [0.52, 5.46] 1.33 [0.11, 15.70] <b>1.98 [1.13, 3.48]</b> Odds Ratio <u>M.H. Fixed, 95% CI</u> 1.08 [0.40, 2.92] 1.50 [0.16, 14.42]		M-H, Fixed, 95% CI	
Study or Subgroup           4elmio, Mika 2014&2018           4elmio, Mika 2014&2018           Perrone, F. 2017           Petenli, R. 2013/2017/2018           Zhang, Y. 2014           fotal (95% CI)           Fotal events           4eterogeneity: Chi <sup>2</sup> = 1.11, c           Fest for overall effect: Z = 0.4           hypertension           Study or Subgroup           4elmio, Mika 2014&2018           Perrone, F. 2017           Peterin, R. 2013/2017/2018           Zhang, Y. 2014           fotal (95% CI)           Fotal events           4eterogeneity: Chi <sup>2</sup> = 0.36, c           Fest for overall effect: Z = 2.3           dyslipidemia           Study or Subgroup           4etering, Mika 2014&2018           Perrone, F. 2017           Peterlin, Mika 2014&2018           Perrone, F. 2017           Peterlin, Mika 2014&2018           Perrone, F. 2017           Peterlin, R. 2013/2017/2018	Events           38           17           21           7           83           ff = 3 (P =           19 (P = 0.6           LRYG           Events           59           19           59           4           141           ff = 3 (P =           38 (P = 0.0           LRYG           Events           20	Total         40           40         20           28         8           96         0.77); I', I'           Total         73           B         Total           168         0.95); I'           B         Total           30         30	Events         36         6         20         20         8         70         2*         0%         LSG         Events         44         111         56         3         3         114         *         0%         LSG         Events         26         Events         26 <th26< th=""> <th20< th=""></th20<></th26<>	Total 41 7 26 9 83 83 17 64 5 154 154	19.2% 14.4% 56.1% 10.2% 100.0% Weight 50.4% 6.3% 100.0% Weight 56.0%	<u>M.H. Fixed, 95% CI</u> 2.64 [0.48, 14.47] 0.94 [0.08, 10.91] 0.90 [0.26, 3.14] 0.88 [0.05, 16.74] 1.24 [0.52, 2.94] 0dds Ratio <u>M.H. Fixed, 95% CI</u> 2.30 [1.07, 4.95] 1.69 [0.52, 5.46] 1.33 [0.11, 15.70] 1.98 [1.13, 3.48] 0dds Ratio <u>M.H. Fixed, 95% CI</u> 1.08 [0.40, 2.92]		M-H, Fixed, 95% CI	
Study or Subgroup           Helmiö, Mika 2014&2018           Perrone, F 2017           Peterli, R 2013/2017/2018           Zhang Y 2014           Fotal (95% CI)           Total events           Heterogeneity: Chi <sup>2</sup> = 1.11, c           Test för överall effect: Z = 0.4           hypertension           Study or Subgroup           Helmiö, Mika 2014&2018           Perrone, F 2017           Perterli, R 2013/2017/2018           Zhang Y 2014           Total events           Heterogeneity: Chi <sup>2</sup> = 0.36, c           Test för överall effect: Z = 2.3           dyslipidemia           Study or Subgroup           Heterogeneity: Chi <sup>2</sup> = 0.36, c           Test för överall effect: Z = 2.3           dyslipidemia           Study or Subgroup           Helmiö, Mika 2014&2018           Perrone, F 2017           Peterli, R 2013/2017/2018           Peterli, R 2013/2017/2018           Zhang Y 2014	Events           38           17           21           7           83           15           16           17           7           11           7           11           7           11           17           11           12           19           19           59           4           141           141           141           141           141           141           12           12           138           141	Total         40           40         20           28         8           96         0.77); F           Mark         73           25         64           6         168           168         168           1043         30           6         53           13         30	Events         36         6         20         8         8         70         *         9         *         11         56         3         3         114         *         =         0%         LSG         Events         244         444         11         56         3         3         114         *         =         0%         LSG         Events         26         444         57         26         3	Total         1           41         7         26           9         83         83           Iotal         68         17           64         5         154           Iotal         40         7           68         13         3	19.2% 14.4% 56.1% 10.2% 100.0% <b>Weight</b> 50.4% 18.1% 25.2% 6.3% 100.0% <b>Weight</b> 56.0% 9.3% 28.4% 6.4%	<u>M.H. Fixed, 95% C1</u> 2.64 [0.48, 14.47] 0.94 [0.08, 10.91] 0.90 [0.26, 3.14] 0.88 [0.05, 16.74] <b>1.24 [0.52, 2.94]</b> 0dds Ratio <u>M.H. Fixed, 95% C1</u> 1.73 [0.45, 6.69] 1.69 [0.52, 5.46] 1.33 [0.11, 15.70] <b>1.98 [1.13, 3.48]</b> 0dds Ratio <u>M.H. Fixed, 95% C1</u> 1.08 [0.40, 2.92] 1.50 [0.16, 14.42] 2.36 [0.71, 7.90] 2.18 [0.17, 27.56]		M-H, Fixed, 95% CI	
Study or Subgroup           Helmio, Mika 2014 & 2018           Helmio, Mika 2014 & 2017           Perrone, F. 2017           Peterli, R. 2013/2017/2018           Zhang, Y. 2014           fotal (95% CI)           Fotal events           Heterogeneity: Chi <sup>2</sup> = 1.11, c           Fest for overall effect: Z = 0.4           hypertension           Study or Subgroup           Helmio, Mika 2014&2018           Perrone, F. 2017           Peteril, R. 2013/2017/2018           Zhang, Y. 2014           Fotal events           Heterogeneity: Chi <sup>2</sup> = 0.36, c           Fest for overall effect: Z = 2.3           dyslipidemia           Study or Subgroup           Helmio, Mika 2014&2018           Perrone, F. 2017           Peteril, R. 2013/2017/2018           Perrone, F. 2017           Peteril, R. 2013/2017/2018           Peteril, S. 2013/2017/2018 <td>Events           38           17           21           7           83           3f = 3 (P =           19 (P = 0.6           LRYG           59           19           59           4           141           3f = 3 (P =           38 (P = 0.0           LRYG           Events           20           4           49           12</td> <td>Total         40           40         20           28         8           96         0.77); I'           Mark         73           73         25           64         6           168         0.95); I'           0.95); I'         168           0.95); I'         168           300         6           53         30</td> <td>Events 36 6 20 8 70 2 10% LSO Events 44 11 56 3 3 114 2 = 0% LSG Events 26 4 57 11</td> <td>Total         1           41         7         26           9         83         83           Iotal         68         17           64         5         154           Iotal         40         7           68         13         3</td> <td>19.2% 14.4% 56.1% 10.2% 100.0% <b>Weight</b> 50.4% 18.1% 25.2% 6.3% 100.0% <b>Weight</b> 56.0% 9.3% 28.4%</td> <td>M.H. Fixed, 95% CI 2.64 [0.48, 14.47] 0.94 [0.08, 10.91] 0.90 [0.26, 3.14] 0.88 [0.05, 16.74] 1.24 [0.52, 2.94] 0.0dds Ratio M.H. Fixed, 95% CI 1.33 [0.11, 15.70] 1.98 [1.13, 3.48] Odds Ratio M.H. Fixed, 95% CI 1.50 [0.40, 2.92] 1.50 [0.16, 14.42] 2.36 [0.71, 7.90]</td> <td></td> <td>M-H, Fixed, 95% CI</td>	Events           38           17           21           7           83           3f = 3 (P =           19 (P = 0.6           LRYG           59           19           59           4           141           3f = 3 (P =           38 (P = 0.0           LRYG           Events           20           4           49           12	Total         40           40         20           28         8           96         0.77); I'           Mark         73           73         25           64         6           168         0.95); I'           0.95); I'         168           0.95); I'         168           300         6           53         30	Events 36 6 20 8 70 2 10% LSO Events 44 11 56 3 3 114 2 = 0% LSG Events 26 4 57 11	Total         1           41         7         26           9         83         83           Iotal         68         17           64         5         154           Iotal         40         7           68         13         3	19.2% 14.4% 56.1% 10.2% 100.0% <b>Weight</b> 50.4% 18.1% 25.2% 6.3% 100.0% <b>Weight</b> 56.0% 9.3% 28.4%	M.H. Fixed, 95% CI 2.64 [0.48, 14.47] 0.94 [0.08, 10.91] 0.90 [0.26, 3.14] 0.88 [0.05, 16.74] 1.24 [0.52, 2.94] 0.0dds Ratio M.H. Fixed, 95% CI 1.33 [0.11, 15.70] 1.98 [1.13, 3.48] Odds Ratio M.H. Fixed, 95% CI 1.50 [0.40, 2.92] 1.50 [0.16, 14.42] 2.36 [0.71, 7.90]		M-H, Fixed, 95% CI	
Study or Subgroup           Helmio, Mika 2014 & 2018           Perrone, F 2017           Peterli, R 2013/2017/2018           Zhang, Y 2014           fotal (95% CI)           Fotal events           Heterogeneity: Chi <sup>2</sup> = 1.11, c           Fest for overall effect: Z = 0.4           hypertension           Study or Subgroup           Helmiö, Mika 2014&2018           Perrone, F 2017           Peterli, R 2013/2017/2018           Chang, Y 2014           Fotal (95% CI)           Petrone, F 2017           Petrone, F 2013/2017/2018           Study or Subgroup           Helmiö, Mika 2014&2018           Petrone, F 2013/2017/2018           Pang Y 2014           Fotal (95% CI)           Fotal (95% CI)           Fotal events	Events           38           17           21           7           83           1f = 3 (P =           19 (P = 0.6           LRYG           Events           59           19           59           4           141           ff = 3 (P =           38 (P = 0.0           LRYG           Events           20           4           9           12           85	Total         40           40         20           28         8           96         0.77); f'           73         3)           B         Total           168         0.95); f           0.95); f         6           168         30           6         53           13         102	Events         36         6         20         20         8         70         = 0%         Esc         Esc         2         6         3         11         11         56         3         3         = 114         11         56         3         3         = 114         2         6         4         4         11         56         3         3         = 114         2         6         4         57         7         11         98 <th 98<="" t<="" td=""><td>Total         1           41         7         26           9         83         83           Iotal         68         17           64         5         154           Iotal         40         7           68         13         3</td><td>19.2% 14.4% 56.1% 10.2% 100.0% <b>Weight</b> 50.4% 18.1% 25.2% 6.3% 100.0% <b>Weight</b> 56.0% 9.3% 28.4% 6.4%</td><td><u>M.H. Fixed, 95% C1</u> 2.64 [0.48, 14.47] 0.94 [0.08, 10.91] 0.90 [0.26, 3.14] 0.88 [0.05, 16.74] <b>1.24 [0.52, 2.94]</b> 0dds Ratio <u>M.H. Fixed, 95% C1</u> 1.73 [0.45, 6.69] 1.69 [0.52, 5.46] 1.33 [0.11, 15.70] <b>1.98 [1.13, 3.48]</b> 0dds Ratio <u>M.H. Fixed, 95% C1</u> 1.08 [0.40, 2.92] 1.50 [0.16, 14.42] 2.36 [0.71, 7.90] 2.18 [0.17, 27.56]</td><td>0.01</td><td>M-H, Fixed, 95% CI</td></th>	<td>Total         1           41         7         26           9         83         83           Iotal         68         17           64         5         154           Iotal         40         7           68         13         3</td> <td>19.2% 14.4% 56.1% 10.2% 100.0% <b>Weight</b> 50.4% 18.1% 25.2% 6.3% 100.0% <b>Weight</b> 56.0% 9.3% 28.4% 6.4%</td> <td><u>M.H. Fixed, 95% C1</u> 2.64 [0.48, 14.47] 0.94 [0.08, 10.91] 0.90 [0.26, 3.14] 0.88 [0.05, 16.74] <b>1.24 [0.52, 2.94]</b> 0dds Ratio <u>M.H. Fixed, 95% C1</u> 1.73 [0.45, 6.69] 1.69 [0.52, 5.46] 1.33 [0.11, 15.70] <b>1.98 [1.13, 3.48]</b> 0dds Ratio <u>M.H. Fixed, 95% C1</u> 1.08 [0.40, 2.92] 1.50 [0.16, 14.42] 2.36 [0.71, 7.90] 2.18 [0.17, 27.56]</td> <td>0.01</td> <td>M-H, Fixed, 95% CI</td>	Total         1           41         7         26           9         83         83           Iotal         68         17           64         5         154           Iotal         40         7           68         13         3	19.2% 14.4% 56.1% 10.2% 100.0% <b>Weight</b> 50.4% 18.1% 25.2% 6.3% 100.0% <b>Weight</b> 56.0% 9.3% 28.4% 6.4%	<u>M.H. Fixed, 95% C1</u> 2.64 [0.48, 14.47] 0.94 [0.08, 10.91] 0.90 [0.26, 3.14] 0.88 [0.05, 16.74] <b>1.24 [0.52, 2.94]</b> 0dds Ratio <u>M.H. Fixed, 95% C1</u> 1.73 [0.45, 6.69] 1.69 [0.52, 5.46] 1.33 [0.11, 15.70] <b>1.98 [1.13, 3.48]</b> 0dds Ratio <u>M.H. Fixed, 95% C1</u> 1.08 [0.40, 2.92] 1.50 [0.16, 14.42] 2.36 [0.71, 7.90] 2.18 [0.17, 27.56]	0.01	M-H, Fixed, 95% CI
Study or Subgroup           Helmiö, Mika 2014&2018           Perrone, F 2017           Peterli, R 2013/2017/2018           Zhang Y 2014           Fotal (95% CI)           Total events           Heterogeneity, Chi <sup>a</sup> = 1.11, c           Test for overall effect: Z = 0.4           hypertension           Study or Subgroup           Helmiö, Mika 2014&2018           Perrone, F 2017           Peterli, R 2013/2017/2018           Zhang Y 2014           Total events           Heterogeneity, Chi <sup>a</sup> = 0.36, c           Test for overall effect: Z = 2.3           dyslipidemia           Study or Subgroup           Heterogeneity, Chi <sup>a</sup> = 0.36, c           Test for overall effect: Z = 2.3           dyslipidemia           Study or Subgroup           Helmiö, Mika 2014&2018           Perrone, F 2017           Peterli, R 2013/2017/2018           Zhang Y 2014           Total (95% CI)           Total events           Heterogeneity, Chi <sup>a</sup> = 1.05, c	Events           38           17           211           7           83           ff=3 (P=           49 (P=0.6           LRYG           Events           59           19           59           4           141           df=3 (P=           38 (P=0.0           LRYG           Events           20           4           12           85           df=3 (P=           85           df=3 (P=	Total         40           40         20           28         8           96         0.77); f           33         73           73         25           64         6           168         0.95); f           70         30           6         33           30         6           53         13           102         0.79); f	Events         36         6         20         20         8         70         = 0%         Esc         Esc         2         6         3         11         11         56         3         3         = 114         11         56         3         3         = 114         2         6         4         4         11         56         3         3         = 114         2         6         4         57         7         11         98 <th 98<="" t<="" td=""><td>Total         1           41         7         26           9         83         83           Iotal         68         17           64         5         154           Iotal         40         7           68         13         3</td><td>19.2% 14.4% 56.1% 10.2% 100.0% <b>Weight</b> 50.4% 18.1% 25.2% 6.3% 100.0% <b>Weight</b> 56.0% 9.3% 28.4% 6.4%</td><td><u>M.H. Fixed, 95% C1</u> 2.64 [0.48, 14.47] 0.94 [0.08, 10.91] 0.90 [0.26, 3.14] 0.88 [0.05, 16.74] <b>1.24 [0.52, 2.94]</b> 0dds Ratio <u>M.H. Fixed, 95% C1</u> 1.73 [0.45, 6.69] 1.69 [0.52, 5.46] 1.33 [0.11, 15.70] <b>1.98 [1.13, 3.48]</b> 0dds Ratio <u>M.H. Fixed, 95% C1</u> 1.08 [0.40, 2.92] 1.50 [0.16, 14.42] 2.36 [0.71, 7.90] 2.18 [0.17, 27.56]</td><td></td><td>M-H, Fixed, 95% CI</td></th>	<td>Total         1           41         7         26           9         83         83           Iotal         68         17           64         5         154           Iotal         40         7           68         13         3</td> <td>19.2% 14.4% 56.1% 10.2% 100.0% <b>Weight</b> 50.4% 18.1% 25.2% 6.3% 100.0% <b>Weight</b> 56.0% 9.3% 28.4% 6.4%</td> <td><u>M.H. Fixed, 95% C1</u> 2.64 [0.48, 14.47] 0.94 [0.08, 10.91] 0.90 [0.26, 3.14] 0.88 [0.05, 16.74] <b>1.24 [0.52, 2.94]</b> 0dds Ratio <u>M.H. Fixed, 95% C1</u> 1.73 [0.45, 6.69] 1.69 [0.52, 5.46] 1.33 [0.11, 15.70] <b>1.98 [1.13, 3.48]</b> 0dds Ratio <u>M.H. Fixed, 95% C1</u> 1.08 [0.40, 2.92] 1.50 [0.16, 14.42] 2.36 [0.71, 7.90] 2.18 [0.17, 27.56]</td> <td></td> <td>M-H, Fixed, 95% CI</td>	Total         1           41         7         26           9         83         83           Iotal         68         17           64         5         154           Iotal         40         7           68         13         3	19.2% 14.4% 56.1% 10.2% 100.0% <b>Weight</b> 50.4% 18.1% 25.2% 6.3% 100.0% <b>Weight</b> 56.0% 9.3% 28.4% 6.4%	<u>M.H. Fixed, 95% C1</u> 2.64 [0.48, 14.47] 0.94 [0.08, 10.91] 0.90 [0.26, 3.14] 0.88 [0.05, 16.74] <b>1.24 [0.52, 2.94]</b> 0dds Ratio <u>M.H. Fixed, 95% C1</u> 1.73 [0.45, 6.69] 1.69 [0.52, 5.46] 1.33 [0.11, 15.70] <b>1.98 [1.13, 3.48]</b> 0dds Ratio <u>M.H. Fixed, 95% C1</u> 1.08 [0.40, 2.92] 1.50 [0.16, 14.42] 2.36 [0.71, 7.90] 2.18 [0.17, 27.56]		M-H, Fixed, 95% CI
Study or Subgroup           Helmio, Mika 2014&2018           Perrone, F 2017           Peterli, R 2013/2017/2018           Zhang, Y 2014           Total (95% CI)           Total events           Heterogeneity: Chi <sup>2</sup> = 1.11, c           Test for overall effect: Z = 0.4           hypertension           Study or Subgroup           Helmiö, Mika 2014&2018           Perrone, F 2017           Peterli, R 2013/2017/2018           Zhang Y 2014           Total (95% CI)           Total events           Heterogeneity: Chi <sup>2</sup> = 0.36, c           Test for overall effect: Z = 2.3           dyslipidemia           Study or Subgroup           Heterogeneity: Chi <sup>2</sup> = 0.37, 2017/2018           Peterin, R 2013/2017/2018           Perrone, F 2017           Peterli, S 2013/2017/2018           Zhang Y 2014           Total (95% CI)           Total events           Heterogeneity: Chi <sup>2</sup> = 1.05, c           Test for overall effect: Z = 1.2	Events           38           17           21           7           11           7           19 (P = 0.6           LRYG           Events           59           19           19           19           19           59           4           183 (P = 0.0           LRYG           Events           20           4           12           20           4           12           85           3f = 3 (P = 25)           25 (P = 0.2)	Total         40           40         28           28         8           96         0.77); f'           Total         73           73         25           64         6           168         0.95); f           Solo         6           168         30           653         13           102         0.79); f           11)         10	Events         36         6         200         8         70         *         90%         LSG         Events         114         11         56         3         3         114         *         20%         LSG         Events         26         4         4         57         11         98         *         = 0%         26         4         57         11         98         *         = 0%         26         4         57         11         98         *         = 0%         98         *         = 0%         26         4         57         11         98         *         = 0%         98         *         = 0%         98         *         20%         10% <th10%< th=""> <th10%< th=""> <th10%< th=""></th10%<></th10%<></th10%<>	Total         41           7         6           9         83           68         17           64         5           154         40           7         68           13         128	19.2% 14.4% 56.1% 10.2% 100.0% <b>Weight</b> 50.4% 18.1% 25.2% 6.3% 100.0% <b>Weight</b> 56.0% 9.3% 28.4% 6.4%	M.H, Fixed, 95% CI 2.64 [0.48, 14.47] 0.94 [0.08, 10.91] 0.90 [0.26, 3.14] 0.88 [0.05, 16.74] 1.24 [0.52, 2.94] 0.0dds Ratio M.H, Fixed, 95% CI 1.33 [0.17, 4.95] 1.69 [0.52, 5.46] 1.33 [0.11, 15.70] 1.98 [1.13, 3.48] Odds Ratio M.H, Fixed, 95% CI 1.08 [0.40, 2.92] 1.08 [0.40, 2.92] 1.08 [0.40, 2.92] 1.08 [0.71, 7.96] 1.55 [0.78, 3.09]	0.01	M-H, Fixed, 95% CI	
Study or Subgroup           Helmiö, Mika 2014&2018           Perrone, F 2017           Peterli, R 2013/2017/2018           Zhang Y 2014           Fotal (95% CI)           Total events           Heterogeneity: Chi <sup>2</sup> = 1.11, c           Test for overall effect: Z = 0.4           hypertension           Study or Subgroup           Helmiö, Mika 2014&2018           Perrone, F 2017           Peterli, R 2013/2017/2018           Zhang Y 2014           Total events           Heterogeneity: Chi <sup>2</sup> = 0.36, c           Test for overall effect: Z = 2.3           dyslipidemia           Study or Subgroup           Heterogeneity: Chi <sup>2</sup> = 0.37, c           Test for overall effect: Z = 2.3           dyslipidemia           Study or Subgroup           Helmiö, Mika 2014&2018           Perrone, F 2017           Peterli, R 2013/2017/2018           Zhang Y 2014           Total (95% CI)           Total events           Peterli, R 2013/2017/2018           Zhang Y 2014           Total (95% CI)           Total events           Heterogeneity: Chi <sup>2</sup> = 1.05, c           Total events           Hetero	Events 38 17 21 7 83 87 83 87 83 87 83 87 83 87 83 87 80 19 9 9 9 9 9 9 9 9 9 9 9 9 9	Total         40           40         20           28         8           96         0.77); f           33         Total           733         25           64         6           168         0.95); f           30         6           533         13           102         0.79); f	Events         36         6         20         20         8         70         2         90%         LSG         Events         26         44         111         56         3         3         2114         26         4         57         111         56         4         57         111         98         26         4         57         111         98         2         98         2         98         2         0%         LSG	Total         41           7         26         9           83         3         3           Image: Total         68         87           68         17         64         5           154         154         3         3           128         13         128         3	19.2% 14.4% 56.1% 10.2% 100.0% <b>Weight</b> 50.4% 18.1% 6.3% 100.0% <b>Weight</b> 56.0% 9.3% 28.4% 6.4% 100.0%	M-H, Fixed, 95% CI 2.64 [0.48, 14.47] 0.94 [0.08, 10.91] 0.90 [0.26, 3.14] 0.88 [0.05, 16.74] 1.24 [0.52, 2.94] 0dds Ratio M-H, Fixed, 95% CI 2.30 [1.07, 4.95] 1.73 [0.45, 6.69] 1.69 [0.52, 5.46] 1.33 [0.11, 15.70] 1.98 [1.13, 3.48] Odds Ratio M-H, Fixed, 95% CI 1.08 [0.40, 2.92] 1.50 [0.16, 14.42] 2.36 [0.71, 7.90] 2.18 [0.17, 27.56] 1.55 [0.78, 3.09] Odds Ratio	0.01	M-H, Fixed, 95% CI 0.1 10 1 Favours LSG Favours LRYGB Odds Ratio M-H, Fixed, 95% CI 0.1 10 1 Favours LSG Favours LRYGB Odds Ratio M-H, Fixed, 95% CI 0.1 10 1 Favours LSG Favours LRYGB Odds Ratio	
Study or Subgroup           Helmiö, Mika 2014&2018           Perrone, F 2017           Peterli, R 2013/2017/2018           Zhang Y 2014           fotal (95% CI)           Total events           Heterogeneity, Chi <sup>2</sup> = 1.11, c           Test for overall effect: Z = 0.4           hypertension           Study or Subgroup           Helmiö, Mika 2014&2018           Perrone, F 2017           Peterli, R 2013/2017/2018           Zhang Y 2014           Total events           Heterogeneity, Chi <sup>2</sup> = 0.36, c           Total events           Heterogeneity, Chi <sup>2</sup> = 0.37, P           Test for overall effect: Z = 2.3           dyslipidemia           Study or Subgroup           Helmiö, Mika 2014&2018           Perrone, F 2017           Peteril, R 2013/2017/2018           Zhang Y 2014           Total (95% CI)           Total events           Heterogeneity, Chi <sup>2</sup> = 1.05, c           Total events           Heterogeneity, Chi <sup>2</sup> = 1.05, f           Total events           Heterogeneity, Chi <sup>2</sup> = 1.05, f           Total events           Heterogeneity, Chi <sup>2</sup> = 1.05, f           Test for overall effect: Z = 1.2	Events           38           17           211           7           83           if = 3 (P =           19 (P = 0.6           LRYG           Pevents           59           19           59           38 (P = 0.0           LRYG           Events           20           4           12           85           if = 3 (P =           20           4           12           85           if = 3 (P =           20           4           12           85           if = 3 (P =           25 (P = 0.2           LRYG	Total         40           40         20           28         8           96         0.77); F           Margin Stress         73           255         64           6         168           168         0.95); F           Total         30           6         53           13         102           0.79); F         11)           B         Total	Events         36         6         20         20         8         70         *= 0%         LSG         Events         24         111         56         3         114         *= 0%         LSG         Events         26         4         57         11         98         *= 0%         LSG         Events         26         4         57         11         98         *= 0%         LSG         Events         26         4         57         11         98         *= 0%         LSG         Events         26         4         57         11         98         *= 0%         LSG         Events         26         4         57         11         98         *= 0%         LSG         Events         26         4         57         11         98         *= 0%         LSG         20%	Total           41           7           26           9           83           Intal           68           13           128           Intal	19.2% 14.4% 56.1% 10.2% 100.0% 50.4% 18.1% 25.2% 6.3% 100.0% <u>Weight</u> 56.0% 9.3% 28.4% 6.4% 100.0%	M.H. Fixed, 95% CI 2.64 [0.48, 14.47] 0.94 [0.08, 10.91] 0.90 [0.26, 3.14] 0.88 [0.05, 16.74] 1.24 [0.52, 2.94] Odds Ratio M.H. Fixed, 95% CI 2.30 [1.07, 4.95] 1.73 [0.45, 6.69] 1.69 [0.52, 5.46] 1.33 [0.11, 15.70] 1.98 [1.13, 3.48] Odds Ratio M.H. Fixed, 95% CI 1.08 [0.40, 2.92] 1.50 [0.16, 14.42] 2.36 [0.71, 7.90] 2.18 [0.17, 27.56] 1.55 [0.78, 3.09] Odds Ratio M.H. Fixed, 95% CI	0.01	M-H, Fixed, 95% CI	
Study or Subgroup           Helmio, Mika 2014&2018           Helmio, Mika 2014&2018           Perrone, F 2017           Peterli, R 2013/2017/2018           Zhang, Y 2014           Total (95% CI)           Total events           Heterogeneity: Chi <sup>2</sup> = 1.11, c           Test for overall effect: Z = 0.4           hypertension           Study or Subgroup           Helmio, Mika 2014&2018           Perrone, F 2017           Peteril, R 2013/2017/2018           Zhang, Y 2014           Total (95% CI)           Total events           Heterogeneity: Chi <sup>2</sup> = 0.36, c           Test for overall effect: Z = 2.3           dyslipidemia           Study or Subgroup           Helmio, Mika 2014&2018           Perrone, F 2017           Perterli, R 2013/2017/2018           Zhang, Y 2014           Total (95% CI)           Total events           Heterogeneity: Chi <sup>2</sup> = 1.05, c           Test for overall effect: Z = 1.2           Sledep apnea           Study or Subgroup           Perrone, F 2017	Events           38           17           21           7           83           17           21           7           19 (P = 0.6           LRYG           99           19           59           19           59           4           141           #f = 3 (P = 0.0           LRYG           Events           20           4           12           85           3f = 3 (P = 0.2           LRYG           Events           25 (P = 0.2           LRYG           Events           12	Total         40           40         28           28         8           96	Events         36         6         20         8         70         8         8         70         8         8         70         8         8         70         8         8         11         56         3         3         114         56         3         11         56         26         44         4         11         56         3         26         457         11         26         457         11         98         26         457         11         98         2         0%         LSG         Events         7         7	Total           41           7           26           9           83           Image: Second State Stat	19.2% 14.4% 56.1% 10.2% 100.0% <b>Weight</b> 50.4% 25.2% 6.3% 100.0% <b>Weight</b> 100.0% <b>Weight</b> 55.3%	M.H. Fixed, 95% CI 2.64 [0.48, 14.47] 0.94 [0.08, 10.91] 0.90 [0.26, 3.14] 0.88 [0.05, 16.74] 1.24 [0.52, 2.94] 0dds Ratio M.H. Fixed, 95% CI 1.33 [0.11, 15.70] 1.98 [1.13, 3.48] Odds Ratio M.H. Fixed, 95% CI 1.08 [0.40, 2.92] 1.50 [0.16, 14.42] 2.36 [0.71, 7.90] 2.18 [0.17, 27.56] 1.55 [0.78, 3.09] Odds Ratio M.H. Fixed, 95% CI 1.37 [0.27, 6.87]	0.01	M-H, Fixed, 95% CI 0.1 10 1 Favours LSG Favours LRYGB Odds Ratio M-H, Fixed, 95% CI 0.1 10 1 Favours LSG Favours LRYGB Odds Ratio M-H, Fixed, 95% CI 0.1 10 1 Favours LSG Favours LRYGB Odds Ratio	
Study or Subgroup           Helmio, Mika 2014&2018           Perrone, F 2017           Peterli, R 2013/2017/2018           Zhang, Y 2014           fotal (95% CI)           Total events           Heterogeneity, Chi <sup>2</sup> = 1.11, c           Test for overall effect: Z = 0.4           hypertension           Study or Subgroup           Helmiö, Mika 2014&2018           Perrone, F 2017           Peterli, R 2013/2017/2018           Zhang, Y 2014           Total (95% CI)           Total events           Heterogeneity, Chi <sup>2</sup> = 0.36, c           Test for overall effect: Z = 2.3           dyslipidemia           Study or Subgroup           Heterogeneity, Chi <sup>2</sup> = 0.37, 2017/2018           Perrone, F 2017           Peterli, R 2013/2017/2018           Zhang, Y 2014           Total events           Heterogeneity, Chi <sup>2</sup> = 1.05, c           Test for overall effect: Z = 1.2           Study or Subgroup           Peterli, R 2013/2017/2018           Total events           Heterogeneity, Chi <sup>2</sup> = 1.05, c           Perrone, F 2017           Perrone, F 2017           Perrone, R 2017           Perrone, S 2017 <td>Events           38           17           21           7           83           17           83           17           83           17           83           17           83           19           59           59           19           59           4           141           ff = 3 (P =           20           4           49           12           85           ff = 3 (P =           25 (P = 0.2           LRYG           Events           21           22           41</td> <td>Total         40           40         20           28         8           96         0.77); f'           Total         73           73         25           64         6           168         0.95); f'           8         30           653         13           102         0.79); f'           11         8           Total         17           43         30</td> <td>Events         36           36         6           20         8           = 0%         LSG           Events         44           11         56           3         = 114           *= 0%         LSG           Events         26           4         57           11         98           *= 0%         LSG           Events         26           457         11           98         *= 0%           LSG         Events           46         457</td> <td>Total           41           7           26           9           83           Image: Second Sec</td> <td>19.2% 14.4% 56.1% 10.2% 100.0% 50.4% 18.1% 25.2% 6.3% 100.0% <u>Weight</u> 56.0% 9.3% 28.4% 6.4% 100.0%</td> <td>M.H. Fixed, 95% CI 2.64 [0.48, 14.47] 0.94 [0.08, 10.91] 0.90 [0.26, 3.14] 0.88 [0.05, 16.74] 1.24 [0.52, 2.94] 0.0dds Ratio M.H. Fixed, 95% CI 1.33 [0.11, 15.70] 1.98 [1.13, 3.48] Odds Ratio M.H. Fixed, 95% CI 1.08 [0.40, 2.92] 1.50 [0.76, 3.09] 2.18 [0.17, 27.56] 1.55 [0.78, 3.09] Odds Ratio M.H. Fixed, 95% CI 1.37 [0.27, 6.87] 0.89 [0.12, 6.62]</td> <td>0.01</td> <td>M-H, Fixed, 95% CI 0.1 10 1 Favours LSG Favours LRYGB Odds Ratio M-H, Fixed, 95% CI 0.1 10 1 Favours LSG Favours LRYGB Odds Ratio M-H, Fixed, 95% CI 0.1 10 1 Favours LSG Favours LRYGB Odds Ratio</td>	Events           38           17           21           7           83           17           83           17           83           17           83           17           83           19           59           59           19           59           4           141           ff = 3 (P =           20           4           49           12           85           ff = 3 (P =           25 (P = 0.2           LRYG           Events           21           22           41	Total         40           40         20           28         8           96         0.77); f'           Total         73           73         25           64         6           168         0.95); f'           8         30           653         13           102         0.79); f'           11         8           Total         17           43         30	Events         36           36         6           20         8           = 0%         LSG           Events         44           11         56           3         = 114           *= 0%         LSG           Events         26           4         57           11         98           *= 0%         LSG           Events         26           457         11           98         *= 0%           LSG         Events           46         457	Total           41           7           26           9           83           Image: Second Sec	19.2% 14.4% 56.1% 10.2% 100.0% 50.4% 18.1% 25.2% 6.3% 100.0% <u>Weight</u> 56.0% 9.3% 28.4% 6.4% 100.0%	M.H. 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Study or Subgroup           Helmiö, Mika 2014&2018           Perrone, F 2017           Peterli, R 2013/2017/2018           Zhang Y 2014           fotal (95% CI)           Total events           Heterogeneity, Chi <sup>2</sup> = 1.11, c           Test for overall effect: Z = 0.4           hypertension           Study or Subgroup           Helmiö, Mika 2014&2018           Perrone, F 2017           Peterli, R 2013/2017/2018           Zhang Y 2014           Total events           Heterogeneity, Chi <sup>2</sup> = 0.36, c           Total events           Heterogeneity, Chi <sup>2</sup> = 0.37, P           Test for overall effect: Z = 2.3           dyslipidemia           Study or Subgroup           Helmiö, Mika 2014&2018           Perrone, F 2017           Peteril, R 2013/2017/2018           Zhang Y 2014           Total (95% CI)           Total events           Heterogeneity, Chi <sup>2</sup> = 1.05, c           Total events           Heterogeneity, Chi <sup>2</sup> = 1.05, f           Total events           Heterogeneity, Chi <sup>2</sup> = 1.05, f           Total events           Heterogeneity, Chi <sup>2</sup> = 1.05, f           Test for overall effect: Z = 1.2	Events           38           17           21           7           83           17           21           7           19 (P = 0.6           LRYG           99           19           59           19           59           4           141           #f = 3 (P = 0.0           LRYG           Events           20           4           12           85           3f = 3 (P = 0.2           LRYG           Events           25 (P = 0.2           LRYG           Events           12	Total         40           40         28           28         8           96	Events         36         6         20         8         70         8         8         70         8         8         70         8         8         70         8         8         11         56         3         3         114         56         3         11         56         26         44         4         11         56         3         26         457         11         26         457         11         98         26         457         11         98         2         0%         LSG         Events         7         7	Total           41           7           26           9           83           Image: Second State Stat	19.2% 14.4% 56.1% 10.2% 100.0% <b>Weight</b> 50.4% 25.2% 6.3% 100.0% <b>Weight</b> 100.0% <b>Weight</b> 55.3%	M.H. Fixed, 95% CI 2.64 [0.48, 14.47] 0.94 [0.08, 10.91] 0.90 [0.26, 3.14] 0.88 [0.05, 16.74] 1.24 [0.52, 2.94] 0dds Ratio M.H. Fixed, 95% CI 1.33 [0.11, 15.70] 1.98 [1.13, 3.48] Odds Ratio M.H. Fixed, 95% CI 1.08 [0.40, 2.92] 1.50 [0.16, 14.42] 2.36 [0.71, 7.90] 2.18 [0.17, 27.56] 1.55 [0.78, 3.09] Odds Ratio M.H. Fixed, 95% CI 1.37 [0.27, 6.87]	0.01	M-H, Fixed, 95% CI 0.1 10 1 Favours LSG Favours LRYGB Odds Ratio M-H, Fixed, 95% CI 0.1 10 1 Favours LSG Favours LRYGB Odds Ratio M-H, Fixed, 95% CI 0.1 10 1 Favours LSG Favours LRYGB Odds Ratio	
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#### Quality of Life (GIQLI and M-A-Q)

The gastrointestinal quality of life index (GIQLI) is a questionnaire for gastrointestinal disease and includes 36 items that assess the following 5 aspects of life: core symptoms, physical items, psychological items, social items, and disease-specific items. The score of the questionnaire ranged from 0 to 144.

The Moorehead–Ardelt quality of life questionnaire II (M-A-QoL Q II) was designed to measure postoperative outcomes of self-perceived QoL in obese patients, including six parts: social relationship, self-esteem, physical activity, satisfaction concerning work, sexuality, and eating behaviors, with a total score that ranges from -3.0 to +3.0.

For GIQLI, no significant difference was observed between the two procedures after 2 and 5 years (at 2 years, WMD = 2.19, 95% CI – 1.33–5.71, P > 0.05 and at 5 years, WMD = 1.59, 95% CI – 3–6.18, P > 0.05). For the M-A-Q, there was also no difference between the outcomes (WMD = 0.07, 95% CI – 0.14–0.29, P > 0.05) (Fig. 7).

# Discussion

This research includes 23 studies with 3863 patients in the LSG group and 3580 patients in the LRYGB group. There have been some previous meta-analyses comparing LRYGB with LSG; however, this study is the first to systematically and comprehensively assess and compare the differences between the two surgical procedures from aspects of weight loss, rate of complications, the resolution/ improvement rate of comorbidities, and quality of life in a single article.

#### Complications

Regarding complications, LRYGB was significantly associated with more early complications than LSG, and the same result was observed for the late complications, which may be related to the difficulty of the LRYGB surgery. Compared with Osland's study [41], we did not perform stratified analyses as the definitions of major or minor complications were not consistent between studies.

# Weight Loss Outcomes

In our research, we analyzed EWL% at different time points after operation. Li [14] and Zhang [15] have previously analyzed the outcomes of weight loss. However, Li did not perform stratified analyses according to time points, and his conclusion is unreliable, as the weight loss differs between time points. Although Zhang performed stratified analyses, the standard of data extraction was different from ours. As a result, there were some differences in our conclusion: we found that there was no significant difference in EWL% between the two surgical procedures during 0.25–2.0-year follow-up, but in the midterm and long term (3 years and 5 years, respectively), the LRYGB group had better effects than the LSG group in weight loss; this finding differs between our study and other studies. In addition, we find that the BMI in eastern country is lower than western country, which may lead to an inherent risk. But as the small number of eastern researches, a further analysis is necessary in future.

#### Comorbidities

In terms of comorbidities, the resolution/improvement rates differ in different periods, but previous studies from Li [14] and Zhang [15] did not analyze the comorbidities according to time points,

Fig. 7 Quality of life	2y-GIQLI	L	RYGB	i.		LSG			Mean Difference		Mean	Difference	
rig. 7 Quanty of file	Study or Subgroup	Mean	SD	Total	Mean	SD	Total	Weight	IV, Fixed, 95% CI		IV, Fixe	ed, 95% Cl	
	Ignat 2016	113.3	15.8	35	114.5	17.6	36	20.8%	-1.20 [-8.93, 6.53]				
	Nickel 2016	114.9	17.8	37	106	17.8	18	12.3%	8.90 [-1.13, 18.93]		-		
	Peterli, R 2013/2017/2018	126.5	14.8	104	124.5	16.9	105	66.9%	2.00 [-2.31, 6.31]			-	
	Total (95% CI)			176			159	100.0%	2.19 [-1.33, 5.71]			-	
	Heterogeneity: Chi <sup>2</sup> = 2.47,	df = 2 (P	= 0.29	$(i); I^2 = 1$	9%					1	1	1 1	-t-
		Test for overall effect: Z = 1.22 (P = 0.22)								-10	-5 Favours LSC	Favours (LRYGB	10
	5y-GIQLI	L	RYGB	LSG		LSG			Mean Difference	Mean Difference			
	Study or Subgroup	Mean	SD	Total	Mean	SD	Total	Weight	IV, Random, 95% CI		IV, Rand	lom, 95% Cl	
	Ignat 2016	111.7	17.8	32	113	16.6	41	20.6%	-1.30 [-9.29, 6.69]			•	
	Lee, W. J 2015	113	20.2	49	114.7	14.7	75	25.9%	-1.70 [-8.26, 4.86]			-	
	Peterli, R 2013/2017/2018	117.9	3.1	104	113.6	4.7	101	53.4%	4.30 [3.21, 5.39]			-	
	Total (95% CI)			185			217	100.0%	1.59 [-3.00, 6.18]			<b>ب</b>	
	Heterogeneity: Tau <sup>2</sup> = 9.95;	Heterogeneity: Tau <sup>2</sup> = 9.95; Chi <sup>2</sup> = 4.87, df = 2 (P = 0.09); I <sup>2</sup> = 59%										0 10 20	
	Test for overall effect: $Z = 0.1$	68 (P = 0	.50)								-20 -10 Favours LSC		в
	M-AQII	U	RYGB		LSG				Mean Difference		Mean D	Mean Difference	
	Study or Subgroup	Mean	SD	Total	Mean	SD	Total	Weight	IV, Fixed, 95% CI		IV, Fixe	d, 95% Cl	
	Helmiö, Mika 2014&2018	0.76	1.01	86	0.85	1.08	90	49.5%	-0.09 [-0.40, 0.22]				
	Ignat 2016	1.4	1.1	32	1.2	1.1	41	18.3%			7		<b>→</b>
	Zhang Y 2014	1.58	0.71	30	1.33	0.8	30	32.2%			-	•	
	Total (95% CI)			148			161	100.0%	0.07 [-0.14, 0.29]		-		
	Heterogeneity: Chi <sup>2</sup> = 2.13,	df = 2 (P	= 0.3	4); 1= 6	6%					- 10	0.05	0 000	0.5
	Test for overall effect: Z = 0.	.65 (P = 0	0.51)							-0.5		0 0.25 Favours LRYGB	0.5

which led to the conclusion that LRYGB is better than LSG. The study from Shoar [42] included the midterm and long-term stages, but there was no short-term stage; additionally, the small number of inclusions was also mentioned as a limitation in Shoar's study. For the first time, we introduced short-term studies and analyzed the midterm and long-term results at the same time. Our results showed that in the short term, LRYGB was superior to LSG in almost all aspects (except for sleep apnea because the sample size was not large enough). After including recent studies [29, 31, 34] of long-term follow-ups, the results showed that there were no differences between the two groups except for hypertension in the midterm and long term. Furthermore, over a longer time frame, the effect on comorbidities is equal to LSG despite better weight loss. The medical therapy may account for the result but we still need more researches.

# **Quality of Life**

This is the first time that quality of life after these two surgeries was summarized and analyzed with a meta-analysis. With GIQLI, we studied the scores 2 years and 5 years after the operation, and the results showed no obvious differences. For M-A-Q II, there was only sufficient data in the fifth year, but there was also no difference. However, we found that Nickel's study [28] reported that the scores in the LRYGB group were significantly lower in the early period (within 6 months) than those in the LSG group. Combined with the results above, these outcomes may be related to the early complications. As LRYGB leads to more early complications, patients might focus on the difference between the two groups decreases after recovery.

Our study has several limitations. Some of the included studies had a small sample size, which may affect the accuracy of this meta-analysis. Re-using a selection of 3–10 studies from the pool of 23 articles for each different research question may lead to the inherent risk of missing relevant publications for each of the individual forest plots. In terms of weight loss, the heterogeneity of analysis at each time point was high, which may be related to different race and region, and different surgical level. Besides, we only searched for English literature; therefore, language bias might exist in this research.

# Conclusion

In this meta-analysis, we found that LRYGB was superior to LSG for comorbidities resolution/improvement in short term, with no difference in the midterm and long term. There was no significant difference in weight loss between LRYGB and LSG in the early period, but LRYGB showed better longterm outcomes in weight loss; in addition, no differences were observed in the quality of life after LRYGB or LSG. The rate of complications was higher for LRYGB than for LSG. Acknowledgments Thanks Dr. Li Bingjie for the guidance in the data extraction and the use of the analysis of software in China.

Author Contributions Design of the study: Hu; collection and analysis: Hu, Sun; discussion of conflicts: Hu, Sun, and Li; manuscript writing: Hu; All authors contributed to the manuscript drafts and gave final approval for this manuscript.

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#### **Compliance with Ethical Standards**

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

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

**Informed Consent Statement** Informed consent does not apply for this study.

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