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Comparative Effects of Bariatric Surgery Techniques on Cardiometabolic Indices: A Cohort Study in Shiraz, Iran

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Abstract

Background

Comparative evidence on the effects of specific bariatric procedures on emerging cardiometabolic risk indices remains limited. This study compared sleeve gastrectomy (SG) and Roux-en-Y gastric bypass (RYGB) regarding changes in anthropometric and novel cardiometabolic indices.

Methods

This retrospective cohort study included 139 patients with morbid obesity who underwent SG (n = 40) or RYGB (n = 99) and completed 12 months of follow-up. Anthropometric and biochemical parameters were assessed preoperatively and at 12 months, and cardiometabolic indices were calculated using standard formulas.

Results

Both procedures produced substantial weight loss at 12 months. Mean total weight loss (%TWL) and excess weight loss (%EWL) were 33.8 ± 7.5% and 81.2 ± 20.3%, respectively, with no significant differences between SG and RYGB (%TWL, $p = 0.30$; %EWL, $p = 0.50$). Despite a higher preoperative BMI in the RYGB group (44.6 ± 5.2 vs. 42.3 ± 4.7 kg/m²; $p = 0.009$), anthropometric improvements were comparable between techniques. Nearly all cardiometabolic indices improved significantly after surgery, except the weight-adjusted waist index ($p = 0.20$). Between-procedure comparisons showed similar improvements in most indices; however, the reduction in lipoprotein combine index (LCI) was significantly greater after RYGB than SG (− 57.2 ± 48.4% vs. −44.7 ± 24.3%; $p = 0.016$). Greater %TWL and %EWL correlated with improvements in BAI, LAP, TyG-BMI, TyG-WC, and TyG-WHtR ($p < 0.05$).

Conclusion

SG and RYGB achieved comparable weight loss and overall cardiometabolic improvements, with WWI as the sole non-responsive index. RYGB resulted in a greater reduction in LCI, while neither technique showed superiority for other cardiometabolic indices.

Introduction

Obesity and overweight are recognized as systemic conditions characterized by excessive and abnormal body fat accumulation, which is associated with adverse health outcomes. Despite considerable efforts to raise awareness, the obesity epidemic persists at an alarming pace (1). Many studies have demonstrated that obesity—particularly central adiposity reflected by increased waist circumference—is significantly associated with coronary heart disease, hypertension, type 2 diabetes, and elevated

mortality risk (2–4). Obesity markedly elevates the risk of cardiovascular disease, leading to earlier onset, prolonged disease duration, and reduced life expectancy compared to individuals with normal weight (5). Obesity is associated with elevated levels of low-density lipoprotein (LDL) and triglycerides, along with reduced levels of high-density lipoprotein (HDL). This dyslipidemic profile facilitates the accumulation of lipids within arterial walls, promoting the formation of atherosclerotic plaques. Consequently, these vascular changes increase peripheral resistance and cardiac workload, thereby accelerating the development of atherosclerosis and ultimately leading to coronary artery disease (6).

Among the various anthropometric indices of obesity, including body mass index (BMI), waist circumference (WC), hip circumference (HC), waist–hip ratio (WHR), and waist-to-height ratio (WHtR), the WHtR has been shown to have a strong association with cardiovascular disease risk (7). Numerous studies have identified novel biomarkers linked to cardiovascular diseases, including the atherogenic index of plasma (AIP), cardiometabolic index (CMI), lipid accumulation product (LAP), lipoprotein combine index (LCI), and triglyceride-glucose (TyG) index. These biomarkers can help predict the risk of cardiovascular disease in high-risk populations, including obese individuals (8–12).

As the majority of obesity cases, particularly morbid obesity, show limited responsiveness to lifestyle interventions and the availability of effective pharmacological therapies remains scarce, bariatric surgery is widely regarded as the most effective and sustainable approach for achieving substantial and long-term weight loss (13). However, the outcomes vary depending on the type of surgery performed. Common bariatric surgeries include sleeve gastrectomy (SG), Roux-en-Y gastric bypass (RYGB), and mini gastric bypass (MGB) (14). RYGB is currently regarded as the gold standard among bariatric procedures, enabling patients to achieve effective weight loss and resolve obesity-related comorbidities (15). Meanwhile, sleeve gastrectomy has become the most frequently performed procedure due to its lower risk of complications (16).

Several studies have explored the association between weight loss and improvements in cardiometabolic risk factors (17–19). A recent meta-analysis found that bariatric surgery significantly reduced the risk of coronary artery disease, heart failure, myocardial infarction, and cardiovascular mortality (20). Although bariatric surgery has been shown to significantly improve several cardiometabolic outcomes, there remains a lack of comparative data on how specific procedures differ in their impact on both conventional and emerging cardiovascular risk indices. Studies assessing markers like the AIP, LAP, TyG index, and CMI across various surgical methods are still limited. Understanding these differences is essential for optimizing patient outcomes and tailoring surgical interventions to individual cardiometabolic profiles. Therefore, this study aimed to evaluate and compare the efficacy of two commonly performed bariatric procedures—RYGB and SG—in improving novel cardiometabolic indices and cardiovascular risk.

Methods

Study Design and Participants

This retrospective cohort study was conducted on patients with morbid obesity who underwent either SG or RYGB at Ghadir Mother and Child Hospital (August 2023 – January 2024). Both male and female patients with a BMI greater than 40 or a BMI of at least 35 accompanied by an obesity-related comorbidity and a history of bariatric surgery (either SG or RYGB) with at least 12 months of follow-up were included. Exclusion criteria comprised a history of inflammatory, infectious, or gastrointestinal diseases, cancer, renal failure, or incomplete medical records.

Anthropometric and Laboratory Assessments

Anthropometric and laboratory assessments were conducted before surgery and 12 months, postoperatively. Venous blood samples were collected after 8 to 10 hours of fasting for laboratory analysis, with the results recorded in the patients' files and the center's database. The fasting blood Sugar (FBS), total cholesterol, triacylglyceride (TG), low-density lipoprotein (LDL) and High-density lipoprotein (HDL) were retrieved. Height was measured using a stadiometer with a precision of 0.1 cm while the participant was in a standing position, and body weight was assessed using a Seca digital scale with a precision of 0.1 kg. Body mass index (BMI) was calculated using the standard formula: BMI = weight (kg) / height² (m²). Waist (WC) and hip (HC) circumferences were obtained using Seca locked measuring tapes. All assessments were carried out by trained nursing personnel following standardized procedures and measurement techniques. To assess weight loss, total weight loss (%TWL) and excess weight loss (%EWL) were calculated as the following: %TWL = (Preoperative weight – postoperative weight) × 100 / Preoperative weight. %EWL = (Preoperative weight – postoperative weight) × 100 / (Preoperative weight – ideal weight). Ideal body weight was calculated based on BMI = 25 kg/m^2.

Cardiometabolic Indices

Cardiometabolic indices were calculated using standard formulas. The Weight-Adjusted-Waist Index (WWI) was determined by dividing the WC in cm by the square root of weight in kg (cm/√kg) (21). The Body Adiposity Index (BAI) was calculated as [HC (cm) / height $(m)^{1.5}$] – 18 (22). The Visceral Adiposity Index (VAI) was determined separately for men and women: for men, the formula used was [WC / (39.68 + 1.88 × BMI)] × (TG (mmol/L) / 1.03) × (1.31 / HDL (mmol/L)), while for women, it was [WC / (36.58 + 1.89 × BMI)] × (TG / 0.81) × (1.52 / HDL) applied (23). The Lipid Accumulation Product (LAP) was calculated as (WC – 65) × TG for men and (WC – 58) × TG for women (24). The Atherogenic Index of Plasma (AIP) was obtained using Log (TG (mmol/L) / HDL-C (mmol/L)), while the Cardiometabolic Index (CMI) was determined as [TG (mmol/L) /HDL-C (mmol/L)] × Waist-to-height ratio (25, 26). The Triglyceride-Glucose Index (TyG Index) was determined as Ln [TG (mg/dL) × FPG (mg/dL)/2] (27), and its variants, TyG-BMI, TyG-WC, and TyG-WHtR, were calculated by multiplying the TyG index by BMI, WC (cm), and waist-to-height ratio, respectively (28). The Lipoprotein Combine Index (LCI) was obtained using the formula TC (mmol/L) × TG (mmol/L) × LDL (mmol/L) / HDL-C (mmol/L) (29). TG to HDL-C ratio was calculated using the formula TG (mmol/L) / HDL-C (mmol/L). To convert triglyceride and cholesterol from mg/dL to mmol/L, we divided the values by 88.57 and 38.67, respectively.

Statistical Analysis

Statistical analyses were performed using SPSS software. Categorical variables were presented as number and percentages, and continuous variables were reported as mean ± standard deviation. The Shapiro-Wilk test was applied to assess the normality of data distribution. Comparisons of quantitative variables between the two groups were conducted using the independent t-test or Mann-Whitney. Chi-square or Fisher's exact test was used for the comparison of categorical variables. For within-group comparisons before and after the operation, the paired t-test or Wilcoxon test was employed. Spearman's rho correlation was used for correlation between EWL%/TWL% and the changes of cardiometabolic indices. A p-value of less than 0.05 was considered statistically significant.

Ethical Considerations

The researchers adhered to the Declaration of Helsinki. Written informed consent was provided from the patients regarding the publication of the study. Ethical approval was obtained from the Ethics Committee of Shiraz University of Medical Sciences (code: IR.SUMS.REC.1404.170). Confidentiality of personal information was strictly maintained.

Result

Baseline Characteristics and Weight Loss Outcomes

A total of 139 patients with morbid obesity were included, of whom 40 (28.8%) underwent sleeve gastrectomy (SG) and 99 (71.2%) underwent Roux-en-Y gastric bypass (RYGB) (Fig. 1). Male sex distribution (15.0% vs 15.2%; $p = 0.9$) and mean age at surgery (36.7 ± 12.8 vs 36.3 ± 10.2 years; $p = 0.9$) were similar between groups. Preoperative body weight did not differ significantly between the SG and RYGB groups (112.5 ± 16.7 kg vs 117.5 ± 19.2 kg; $p = 0.16$). Both groups achieved substantial weight reduction at 12 months ($p < 0.001$ for before vs 1 year in both groups), with a mean total weight loss (%TWL) of 34.2 ± 9.5% and excess weight loss (%EWL) of 81.2 ± 20.3% for the entire cohort. Neither %TWL (32.8 ± 8.8% for SG vs 34.6 ± 7.6% for RYGB; $p = 0.3$) nor %EWL (82.7 ± 23.9% for SG vs 80.6 ± 18.8% for RYGB; $p = 0.5$) differed significantly between the two procedures (Table 1).

Table 1
Demographic and anthropometric characteristics of participations.

Variables; N (%), mean ± SD, or median [IQR]	**Total**	**N**	**Sleeve gastrectomy**	**N**	**Roux-en-Y bypass**	**N**	***p* for sleeve gastrectomy vs Roux-en-Y bypass**
Male gender	21 (15.1%)	139	6 (15.0%)	40	15 (15.2%)	99	0.9
Age at surgery (year)	36.4 ± 11.0	139	36.7 ± 12.8	40	36.3 ± 10.2	99	0.9
Weight (kg)							
Before	116.2 ± 18.5	139	112.5 ± 16.7	40	117.5 ± 19.2	99	0.16
1 year	76.5 ± 13.2		75.7 ± 14.3		76.9 ± 12.8		0.6
% change	-34.82 ± 5.5		-32.8 ± 4.5		-34.6 ± 7.3		0.2
p for before vs 1 year	< 0.001		< 0.001		< 0.001		
TWL%	34.2 ± 9.5	139	32.8 ± 8.8	40	34.6 ± 7.6	99	0.3
EWL%	81.2 ± 20.3	139	82.7 ± 23.9	40	80.6 ± 18.8	99	0.5
BMI (kg/m^2)							
Before	44.0 ± 5.2	139	42.3 ± 4.7	40	44.6 ± 5.2	99	0.009
1 year	29.1 ± 4.4		28.4 ± 4.7		29.3 ± 4.3		0.3
% change	-33.9 ± 7.5		-32.9 ± 8.9		-34.3 ± 6.9		0.3
p for before vs 1 year	< 0.001		< 0.001		< 0.001		
Waist circumference (cm)							
Before	124.0 ± 12.4	120	121.5 ± 11.8	35	125.6 ± 12.7	85	0.2

BMI body mass index, EWL excess weight loss, IQR interquartile range, N number, SD standard deviation, TWL total weight loss.

Variables; N (%), mean ± SD, or median [IQR]	Total	N	Sleeve gastrectomy	N	Roux-en-Y bypass	N	*p* for sleeve gastrectomy vs Roux-en-Y bypass
1 year	100.0 ± 9.5		96.7 ± 9.8		101.8 ± 9.0		0.07
% change	-18.9 ± 8.6		-19.8 ± 9.8		-18.4 ± 8.1		0.6
p for before vs 1 year	< 0.001		< 0.001		< 0.001		
Hip circumference (cm)							
Before	131.5 ± 10.6	120	127.4 ± 10.1	35	133.6 ± 10.3	85	0.048
1 year	108.6 ± 7.7		105.9 ± 6.7		110.1 ± 7.8		0.16
% change	-17.1 ± 5.9		-16.5 ± 6.3		-17.4 ± 5.7		0.6
p for before vs 1 year	< 0.001		< 0.001		< 0.001		

BMI body mass index, EWL excess weight loss, IQR interquartile range, N number, SD standard deviation, TWL total weight loss.

Anthropometric Changes: BMI, Waist and Hip Circumference

BMI decreased significantly in both groups after surgery ($p < 0.001$ for both), reaching 28.4 ± 4.7 kg/m² in the SG group and 29.3 ± 4.3 kg/m² in the RYGB group at 12 months ($p = 0.3$ between groups), with comparable percentage reductions (-32.9 ± 8.9% vs -34.3 ± 6.9%; $p = 0.3$). Waist circumference (WC) was similar between groups preoperatively (121.5 ± 11.8 cm for SG vs 125.6 ± 12.7 cm for RYGB; $p = 0.2$) and decreased significantly in both groups by 12 months ($p < 0.001$ for both); the between-group difference approached but did not reach significance at 12 months (96.7 ± 9.8 cm vs 101.8 ± 9.0 cm; $p = 0.07$), and percentage change in WC did not differ significantly between groups (-19.8 ± 9.8% for SG vs -18.4 ± 8.1% for RYGB; $p = 0.6$). Hip circumference (HC) was significantly greater in the RYGB group at baseline (127.4 ± 10.1 cm vs 133.6 ± 10.3 cm; $p = 0.048$) and decreased significantly in both groups postoperatively ($p < 0.001$ for both), with no significant between-group difference at 12 months (105.9 ± 6.7 cm vs 110.1 ± 7.8 cm; $p = 0.16$) or in percentage change (-16.5 ± 6.3% vs -17.4 ± 5.7%; $p = 0.6$) (Table 1).

Fasting Blood Sugar (FBS)

Fasting blood sugar (FBS) was comparable between the SG and RYGB groups at baseline (96.3 ± 10.8 mg/dL vs 102.8 ± 18.7 mg/dL; $p = 0.2$) and decreased significantly from baseline to 12 months in both groups (SG, $p = 0.002$; RYGB, $p < 0.001$), reaching 85.2 ± 6.1 mg/dL and 82.8 ± 8.0 mg/dL, respectively ($p = 0.3$ between groups at 12 months). The percentage reduction in FBS was numerically greater after RYGB than SG (-17.6 ± 13.3% vs -10.6 ± 10.7%), although this difference did not reach statistical significance ($p = 0.071$) (Table 2).

Table 2
Cardiometabolic indices.

Variables; N (%), mean ± SD, or median [IQR]	Total	N	Sleeve gastrectomy	N	Roux-en-Y bypass	N	*p* for sleeve gastrectomy vs Roux-en-Y bypass
FBS							
Before	101.2 ± 17.3	120	96.3 ± 10.8	35	102.8 ± 18.7	85	0.2
1 year	83.4 ± 7.6		85.2 ± 6.1		82.8 ± 8.0		0.3
% change	-15.9 ± 13.0		-10.6 ± 10.7		-17.6 ± 13.3		0.071
p for before vs 1 year	< 0.001		0.002		< 0.001		
WWI							
Before	11.6 ± 0.8	111	11.4 ± 0.7	31	11.7 ± 0.8	80	0.2
1 year	11.5 ± 0.8		11.1 ± 0.9		11.6 ± 0.6		0.006
% change	-1.0 ± 8.2		-2.5 ± 8.7		-0.2 ± 8.0		0.3
p for before vs 1 year	0.2		0.2		0.7		
BAI							
Before	46.1 ± 6.9	111	42.5 ± 5.9	31	47.9 ± 6.7	80	0.008
1 year	35.0 ± 5.7		32.4 ± 4.9		36.3 ± 5.7		0.021
% change	-23.8 ± 7.9		-23.4 ± 8.7		-23.9 ± 7.6		0.7
p for before vs 1 year	< 0.001		< 0.001		< 0.001		
VAI							

AIP Atherogenic Index of Plasma, BAI Body Adiposity Index, CMI Cardiometabolic Index, FBS fasting blood sugar, IQR interquartile range, LAP Lipid Accumulation Product, LCI Lipoprotein Combine Index, N number, SD standard deviation, TG/HDL-C ratio triglyceride to high-density lipoprotein ratio, TyG-BMI Triglyceride-Glucose-body mass index, TyG Index Triglyceride-Glucose Index, TyG-WC Triglyceride-Glucose-waist circumference, TyG-WHtR Triglyceride-Glucose-waist-to-height ratio, VAI Visceral Adiposity Index, WWI Wight-Adjusted-Waist Index.

Variables; N (%), mean ± SD, or median [IQR]	Total	N	Sleeve gastrectomy	N	Roux-en-Y bypass	N	*p* for sleeve gastrectomy vs Roux-en-Y bypass
Before	3.2 ± 2.6	121	3.0 ± 3.6	32	3.3 ± 1.7	89	0.030
1 year	1.5 ± 0.9		1.5 ± 1.1		1.5 ± 0.6		0.5
% change	-42.9 ± 24.1		-37.0 ± 25.0		-47.1 ± 23.5		0.3
p for before vs 1 year	< 0.001		0.011		0.001		
LAP							
Before	109.8 ± 68.5	124	96.2 ± 105.9	34	117.9 ± 33.4	90	0.008
1 year	44.5 ± 35.7		43.4 ± 56.7		45.1 ± 15.9		0.022
% change	-58.1 ± 18.0		-54.7 ± 25.4		-60.1 ± 12.3		0.5
p for before vs 1 year	< 0.001		0.011		0.001		
AIP							
Before	0.16 ± 0.23	119	0.09 ± 0.27	32	0.19 ± 0.20	87	0.15
1 year	-0.14 ± 0.22		-0.14 ± 0.20		-0.14 ± 0.23		0.5
% change	-266.0 ± 665.8		-205.5 ± 337.8		-288.7 ± 755.5		0.5
p for before vs 1 year	< 0.001		< 0.001		< 0.001		
CMI							
Before	1.3 ± 1.0	122	1.2 ± 1.4	30	1.4 ± 0.7	82	0.042
1 year	0.49 ± 0.29		0.47 ± 0.40		0.5 ± 0.2		0.16

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Variables; N (%), mean ± SD, or median [IQR]	Total	N	Sleeve gastrectomy	N	Roux-en-Y bypass	N	*p* for sleeve gastrectomy vs Roux-en-Y bypass
% change	-55.9 ± 19.1		-50.9 ± 18.4		-59.4 ± 19.5		0.3
p for before vs 1 year	< 0.001		0.008		0.001		
TyG Index							
Before	8.8 ± 0.4	119	8.6 ± 0.4	34	8.8 ± 0.4	85	0.058
1 year	8.0 ± 0.4		8.0 ± 0.4		8.0 ± 0.4		0.7
% change	-7.9 ± 5.9		-6.0 ± 4.6		-8.5 ± 6.2		0.16
p for before vs 1 year	< 0.001		< 0.001		< 0.001		
TyG-BMI							
Before	389.5 ± 52.2	119	357.4 ± 39.4	34	400.4 ± 51.9	85	0.006
1 year	235.9 ± 34.1		227.0 ± 28.5		239.0 ± 35.5		0.3
% change	-39.0 ± 7.3		-36.1 ± 7.6		-40.0 ± 7.0		0.088
p for before vs 1 year	< 0.001		< 0.001		< 0.001		
TyG-WC							
Before	1085.7 ± 149.6	121	983.4 ± 91.9	31	1148.7 ± 145.3	90	0.010
1 year	788.1 ± 88.4		725.0 ± 75.2		826.9 ± 73.7		0.007
% change	-27.4 ± 9.5		-26.3 ± 12.0		-28.0 ± 8.0		0.8
p for before vs 1 year	< 0.001		0.001		< 0.001		
TyG-WHtR							

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Variables; N (%), mean ± SD, or median [IQR]	Total	N	Sleeve gastrectomy	N	Roux-en-Y bypass	N	*p* for sleeve gastrectomy vs Roux-en-Y bypass
Before	6.7 ± 0.8	121	6.1 ± 0.5	31	7.1 ± 0.7	90	0.005
1 year	4.9 ± 0.5		4.5 ± 0.4		5.1 ± 0.5		0.010
% change	-26.9 ± 8.7		-26.2 ± 10.1		-28.32 ± 6.5		0.6
p for before vs 1 year	< 0.001		0.001		< 0.001		
LCI							
Before	24.0 ± 20.7	111	23.6 ± 30.1	31	24.1 ± 16.5	80	0.2
1 year	7.5 ± 7.8		10.8 ± 11.7		6.3 ± 5.5		0.11
% change	-53.9 ± 43.3		-44.7 ± 24.3		-57.2 ± 48.4		0.016
p for before vs 1 year	< 0.001		0.002		< 0.001		
TG/HDL-C ratio							
Before	1.6 ± 1.0	119	1.5 ± 1.2	34	1.7 ± 0.9	85	0.10
1 year	0.79 ± 0.35		0.80 ± 0.43		0.79 ± 0.32		0.5
% change	-43.9 ± 26.7		-37.6 ± 23.5		-46.3 ± 27.7		0.2
p for before vs 1 year	< 0.001		0.001		< 0.001		

AIP Atherogenic Index of Plasma, BAI Body Adiposity Index, CMI Cardiometabolic Index, FBS fasting blood sugar, IQR interquartile range, LAP Lipid Accumulation Product, LCI Lipoprotein Combine Index, N number, SD standard deviation, TG/HDL-C ratio triglyceride to high-density lipoprotein ratio, TyG-BMI Triglyceride-Glucose-body mass index, TyG Index Triglyceride-Glucose Index, TyG-WC Triglyceride-Glucose-waist circumference, TyG-WHtR Triglyceride-Glucose-waist-to-height ratio, VAI Visceral Adiposity Index, WWI Wight-Adjusted-Waist Index.

Weight-Adjusted-Waist Index (WWI)

The weight-adjusted-waist index (WWI) was similar between groups at baseline (11.4 ± 0.7 for SG vs 11.7 ± 0.8 for RYGB; p = 0.2). Unlike the other cardiometabolic indices assessed, WWI did not change significantly from baseline to 12 months in either group (SG, p = 0.2; RYGB, p = 0.7), and the percentage change was small and did not differ significantly between groups (-2.5 ± 8.7% for SG vs -0.2 ± 8.0% for

RYGB; p = 0.3). However, the absolute WWI value at 12 months was significantly lower in the SG group than in the RYGB group (11.1 ± 0.9 vs 11.6 ± 0.6; p = 0.006) (Table 2).

Body Adiposity Index (BAI)

Body adiposity index (BAI) was significantly lower in the SG group than in the RYGB group at baseline (42.5 ± 5.9 vs 47.9 ± 6.7; p = 0.008) and remained significantly lower at 12 months (32.4 ± 4.9 vs 36.3 ± 5.7; p = 0.021). BAI decreased significantly from baseline to 12 months in both groups (p < 0.001 for both), with comparable percentage reductions between SG and RYGB (-23.4 ± 8.7% vs -23.9 ± 7.6%; p = 0.7) (Table 2).

Visceral Adiposity Index (VAI)

Visceral adiposity index (VAI) was significantly lower in the SG group than in the RYGB group at baseline (3.0 ± 3.6 vs 3.3 ± 1.7; p = 0.030), decreasing significantly in both groups by 12 months (SG, p = 0.011; RYGB, p = 0.001) to comparable values (1.5 ± 1.1 vs 1.5 ± 0.6; p = 0.5). The percentage reduction in VAI was numerically greater after RYGB (-47.1 ± 23.5%) than SG (-37.0 ± 25.0%), but the difference was not statistically significant (p = 0.3) (Table 2).

Lipid Accumulation Product (LAP)

Lipid accumulation product (LAP) was significantly lower in the SG group than in the RYGB group at baseline (96.2 ± 105.9 vs 117.9 ± 33.4; p = 0.008) and remained significantly lower at 12 months (43.4 ± 56.7 vs 45.1 ± 15.9; p = 0.022). LAP decreased significantly from baseline to 12 months in both groups (SG, p = 0.011; RYGB, p = 0.001), with percentage reductions of -54.7 ± 25.4% for SG and – 60.1 ± 12.3% for RYGB, a difference that was not statistically significant (p = 0.5) (Table 2).

Atherogenic Index of Plasma (AIP)

The atherogenic index of plasma (AIP) did not differ significantly between groups at baseline (0.09 ± 0.27 for SG vs 0.19 ± 0.20 for RYGB; p = 0.15) or at 12 months (-0.14 ± 0.20 vs -0.14 ± 0.23; p = 0.5). AIP decreased significantly from baseline to 12 months in both groups (p < 0.001 for both). Because AIP values crossed zero, percentage changes were large in magnitude (-205.5 ± 337.8% for SG vs -288.7 ± 755.5% for RYGB) but did not differ significantly between groups (p = 0.5) (Table 2).

Cardiometabolic Index (CMI)

The cardiometabolic index (CMI) was significantly lower in the SG group than in the RYGB group at baseline (1.2 ± 1.4 vs 1.4 ± 0.7; p = 0.042), but this difference was no longer significant at 12 months (0.47 ± 0.40 vs 0.5 ± 0.2; p = 0.16). CMI decreased significantly from baseline to 12 months in both groups (SG, p = 0.008; RYGB, p = 0.001), with a numerically greater percentage reduction after RYGB (-59.4 ± 19.5%) than SG (-50.9 ± 18.4%), although the between-group difference was not statistically significant (p = 0.3) (Table 2).

Triglyceride-Glucose Index and Its Derivatives (TyG Index, TyG-BMI, TyG-WC, TyG-WHtR)

The triglyceride-glucose (TyG) index showed a borderline, non-significant difference between the SG and RYGB groups at baseline (8.6 ± 0.4 vs 8.8 ± 0.4; p = 0.058), converging to similar values at 12 months (8.0 ± 0.4 for both; p = 0.7). TyG index decreased significantly from baseline to 12 months in both groups (p < 0.001 for both), with comparable percentage reductions (-6.0 ± 4.6% for SG vs -8.5 ± 6.2% for RYGB; p = 0.16). TyG-BMI was significantly lower in the SG group at baseline (357.4 ± 39.4 vs 400.4 ± 51.9; p = 0.006), though the difference was no longer significant at 12 months (227.0 ± 28.5 vs 239.0 ± 35.5; p = 0.3). TyG-BMI decreased significantly in both groups (p < 0.001 for both), with percentage reductions of -36.1 ± 7.6% for SG and – 40.0 ± 7.0% for RYGB, a difference approaching but not reaching significance (p = 0.088). TyG-WC was significantly lower in the SG group at both baseline (983.4 ± 91.9 vs 1148.7 ± 145.3; p = 0.010) and 12 months (725.0 ± 75.2 vs 826.9 ± 73.7; p = 0.007) compared with RYGB. Both groups showed significant reductions from baseline to 12 months (SG, p = 0.001; RYGB, p < 0.001), with comparable percentage change (-26.3 ± 12.0% vs -28.0 ± 8.0%; p = 0.8). Similarly, TyG-WHtR was significantly lower in the SG group at baseline (6.1 ± 0.5 vs 7.1 ± 0.7; p = 0.005) and at 12 months (4.5 ± 0.4 vs 5.1 ± 0.5; p = 0.010) compared with RYGB, with significant within-group reductions in both groups (SG, p = 0.001; RYGB, p < 0.001) and comparable percentage change between groups (-26.2 ± 10.1% vs -28.3 ± 6.5%; p = 0.8) (Table 2).

Lipoprotein Combine Index (LCI)

The lipoprotein combine index (LCI) did not differ significantly between groups at baseline (23.6 ± 30.1 for SG vs 24.1 ± 16.5 for RYGB; p = 0.2) or at 12 months (10.8 ± 11.7 vs 6.3 ± 5.5; p = 0.11). LCI decreased significantly from baseline to 12 months in both groups (SG, p = 0.002; RYGB, p < 0.001). Notably, the percentage reduction in LCI was significantly greater after RYGB than SG (-57.2 ± 48.4% vs -44.7 ± 24.3%; p = 0.016), representing the only cardiometabolic index that showed a statistically significant between-procedure difference in the magnitude of change (Table 2).

TG/HDL-C Ratio

The TG/HDL-C ratio was similar between groups at baseline (1.5 ± 1.2 for SG vs 1.7 ± 0.9 for RYGB; p = 0.10) and at 12 months (0.80 ± 0.43 vs 0.79 ± 0.32; p = 0.5). The ratio decreased significantly from baseline to 12 months in both groups (SG, p = 0.001; RYGB, p < 0.001), with a numerically but not statistically greater percentage reduction after RYGB (-46.3 ± 27.7%) than SG (-37.6 ± 23.5%; p = 0.2) (Table 2).

Correlations Between Weight Loss and Changes in Cardiometabolic Indices

Greater %TWL was significantly correlated with greater improvements in BAI (r=-0.610, p < 0.001), LAP (r=-0.776, p < 0.001), TyG-BMI (r=-0.869, p < 0.001), TyG-WC (r=-0.749, p < 0.001), and TyG-WHtR (r=-0.749,

p < 0.001). Similarly, greater %EWL was significantly correlated with improvements in BAI (r=-0.510, p < 0.001), LAP (r=-0.697, p < 0.001), TyG-BMI (r=-0.625, p < 0.001), TyG-WC (r=-0.516, p = 0.017), and TyG-WHtR (r=-0.516, p = 0.017). No significant correlations were observed between %TWL or %EWL and changes in FBS, WWI, VAI, AIP, CMI, TyG index, LCI, or TG/HDL-C ratio (all p > 0.05) (Table 3).

Table 3
Correlation between total weight loss/excess weight loss and the changes of cardiometabolic indices.

Changes of cardiometabolic indices	**%TWL**		**%EWL**	
	Correlation coefficient	***p***	**Correlation coefficient**	***p***
FBS	-0.080	0.5	-0.104	0.4
WWI	-0.223	0.12	-0.125	0.4
BAI	-0.610	< 0.001	-0.510	< 0.001
VAI	-0.219	0.3	-0.112	0.6
LAP	-0.776	< 0.001	-0.697	< 0.001
AIP	-0.145	0.3	-0.045	0.7
CMI	-0.304	0.16	-0.177	0.4
TyG Index	-0.208	0.12	-0.173	0.2
TyG-BMI	-0.869	< 0.001	-0.625	< 0.001
TyG-WC	-0.749	< 0.001	-0.516	0.017
TyG-WHtR	-0.749	< 0.001	-0.516	0.017
LCI	-0.207	0.15	-0.197	0.18
TG/HDL-C ratio	-0.111	0.4	-0.081	0.5

AIP Atherogenic Index of Plasma, BAI Body Adiposity Index, CMI Cardiometabolic Index, FBS fasting blood sugar, EWL excess weight loss, LAP Lipid Accumulation Product, LCI Lipoprotein Combine Index, N number, TG/HDL-C ratio triglyceride to high-density lipoprotein ratio, TWL total weight loss, TyG-BMI Triglyceride-Glucose-body mass index, TyG Index Triglyceride-Glucose Index, TyG-WC Triglyceride-Glucose-waist circumference, TyG-WHtR Triglyceride-Glucose-waist-to-height ratio, VAI Visceral Adiposity Index, WWI Wight-Adjusted-Waist Index.

Discussion

In this cohort study of 139 patients with morbid obesity, bariatric surgery was associated with significant improvements in cardiometabolic health. The findings demonstrated that both bariatric procedures effectively reduced anthropometric indices and lowered cardiovascular risk by improving markers such as CMI, LAP, LCI, and other related factors. Weight reduction was comparable between SG and RYGB,

and the only factor with significant change difference between these two operations was LCI – the reduction was more pronounced in RYGB.

The findings of this study are consistent with previous research investigating the relationship between bariatric surgery and cardiometabolic parameters in individuals with morbid obesity. For instance, Shadnoush et al. conducted a cohort study to assess the effects of bariatric surgery on atherogenicity and insulin resistance in individuals with class II obesity. They monitored 443 severely obese patients who underwent SG, RYGB, or OAGB for 12 months postoperatively. Their results demonstrated that, in addition to reductions in anthropometric indices, markers associated with atherosclerosis—such as AIP, TyG index, LCI, AC, CHOLINDEX, CRI-I, CRI-II, and the TG-to-HDL-C ratio—showed significant improvements compared to baseline values (30). Similarly, a retrospective cohort study by Tabesh et al. on 485 individuals with severe obesity, found that bariatric surgery had a significant positive impact on cardiometabolic risk factors and comorbidities over a 12-month follow-up period. Their findings also indicated that RYGB and OAGB were more effective than SG in reducing weight, BMI, fat mass, and %TWL, (17). Our study, however, demonstrated comparable results between RYGB and SG regarding weight reduction.

Although Shadnoush et al. and Tabesh et al. have previously investigated the impact of bariatric surgery on cardiometabolic risk factors in Iranian populations with severe obesity, important gaps remain that the present study addresses. Shadnoush et al. focused primarily on atherogenicity and insulin resistance markers—including AIP, TyG index, LCI, AC, CHOLINDEX, CRI-I, CRI-II, and TG-to-HDL-C ratio—across three surgical techniques (SG, RYGB, and OAGB) without directly comparing the magnitude of change between procedures for each index (30). Tabesh et al., in a larger cohort, examined broader cardiometabolic risk factors and comorbidity resolution but concentrated on weight-related outcomes and did not evaluate several of the newer adiposity- and lipid-based indices increasingly recognized for cardiovascular risk prediction (17). In contrast, the present study specifically contrasts SG and RYGB—the two most commonly performed bariatric procedures—across a comprehensive panel of both anthropometric and novel cardiometabolic indices, including the weight-adjusted-waist index (WWI), body adiposity index (BAI), visceral adiposity index (VAI), lipid accumulation product (LAP), cardiometabolic index (CMI), lipoprotein combine index (LCI), and the triglyceride-glucose index along with its body mass index-, waist circumference-, and waist-to-height ratio-adjusted variants (TyG-BMI, TyG-WC, TyG-WHtR). Furthermore, unlike prior studies, we directly assessed the correlation between the degree of weight loss (%TWL and %EWL) and the improvement in each cardiometabolic index, providing insight into which markers are most closely linked to surgical weight loss outcomes. This procedure-specific, index-by-index comparative approach offers a more granular understanding of how SG and RYGB differentially affect cardiometabolic risk, information that is essential for individualized surgical decision-making.

Moreover, multiple studies have reported rapid postoperative improvements in metabolic parameters, particularly in lipid profiles—such as reductions in total cholesterol, LDL cholesterol, and triglycerides—as well as enhanced glycemic control (31, 32). Several mechanisms may underlie the observed improvements in cardiometabolic risk following bariatric surgery. Weight loss typically improves

peripheral insulin sensitivity, thereby enhancing glycemic control and contributing to the reduction of cardiovascular risk factors (33). Additionally, bariatric surgery induces significant changes in gut microbiota composition, which plays a crucial role in metabolic regulation (34). Postoperative shifts in microbial populations—particularly an increase in *Bacteroidetes* and a decrease in *Firmicutes*—have been associated with improved glucose metabolism and lipid profiles (35). These microbial changes can enhance bile acid metabolism, increase energy expenditure, and further contribute to cardiometabolic improvement (35).

Notably, post-surgical weight loss is primarily associated with decreased visceral fat, lower white blood cell counts, and reduced circulating levels of molecules involved in endothelial dysfunction and inflammation (36). Inflammatory markers, such as the erythrocyte sedimentation rate (ESR)—an important predictor of coronary mortality—also decline. In addition, bariatric surgery increases adipokine levels, particularly adiponectin, which enhances insulin sensitivity while reducing high-sensitivity C-reactive protein (hs-CRP) (37). Beyond inflammation, bariatric surgery modulates hormonal responses that influence metabolic health. Increased levels of glucagon-like peptide-1 (GLP-1) and peptide YY (PYY) after surgery contribute to appetite suppression and improved insulin sensitivity (38). Conversely, the reduction of ghrelin, a hunger-stimulating hormone, plays a crucial role in long-term weight maintenance and metabolic benefits (39).

Furthermore, research suggests that bariatric surgery mitigates atherogenic processes in individuals with morbid obesity by decreasing oxidative stress, improving glucose metabolism, and addressing atherogenic dyslipidemia—ultimately reducing the risk of atherosclerosis and CVD (40). A meta-analysis of 49 studies found that bariatric surgery significantly lowers the risk of coronary artery disease, myocardial infarction, heart failure, and cardiovascular disease-specific mortality, though its impact on atrial fibrillation was not statistically significant (20). Similarly, a 2022 meta-analysis involving 39 cohort studies demonstrated that bariatric surgery reduces both mortality and the incidence of cardiovascular disease in patients with obesity compared to non-surgical treatments (41).

Despite these promising findings, the present study has certain limitations. Firstly, dietary habits and physical activity levels of participants were not assessed, which could influence cardiometabolic outcomes. Secondly, the lack of a matched control group that did not undergo surgery limits the precision of our conclusions. Additionally, significant amount of missing data, leading to small sample sizes in each analysis, is a major limitation of this investigation. Future research should focus on the long-term sustainability of cardiometabolic improvements following bariatric surgery, particularly in relation to lifestyle modifications. Additionally, exploring individualized approaches for selecting the most effective surgical technique based on genetic and metabolic profiles could enhance patient outcomes.

Conclusion

In conclusion, no significant differences in anthropometric variables were found between SG and RYGB. In addition, one year following surgery, significant reductions were observed across all cardiometabolic parameters, with the exception of WWI. However, regarding the comparison between SG and RYGB, LCI was the only index with a significant difference. The correlation between %TWL/%EWL and the changes of cardiometabolic indices indicated significant correlations between %TWL/%EWL and BAI, LAP, TyG-BMI, TyG-WC, and TyG-WHtR. Further research with larger sample sizes are suggested to compare cardiometabolic indices between different bariatric surgery techniques.

Declarations

Data Availability statement:

Data and materials are available with the corresponding author on reasonable request

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Author Contribution

B.H. and N.H. Conceptualization, Writing, Reviewing, And Editing Original and Final Draft

N.H. Formal Analysis

M.A., L.A. and N.M.V Data Curation, Investigation, Writing, Reviewing, And Editing Original Draft

M.A. – Conceptualization and Supervision

All authors approved the final version of the manuscript.

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During the preparation of the manuscript, the authors used ChatGPT and Claude, AI language model developed by OpenAI, to assist with language refinement. After using these tools, the authors carefully reviewed and edited all content, ensuring its accuracy, relevance, and alignment with the original research. The authors take full responsibility for the content of the publication.

Conflict of Interest:

None

Ethical Approval:

Ethical approval was obtained from the Ethics Committee of Shiraz University of Medical Sciences (code: IR.SUMS.REC.1404.170). Confidentiality of personal information was strictly maintained.

Clinical trial number:

not applicable

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Figures

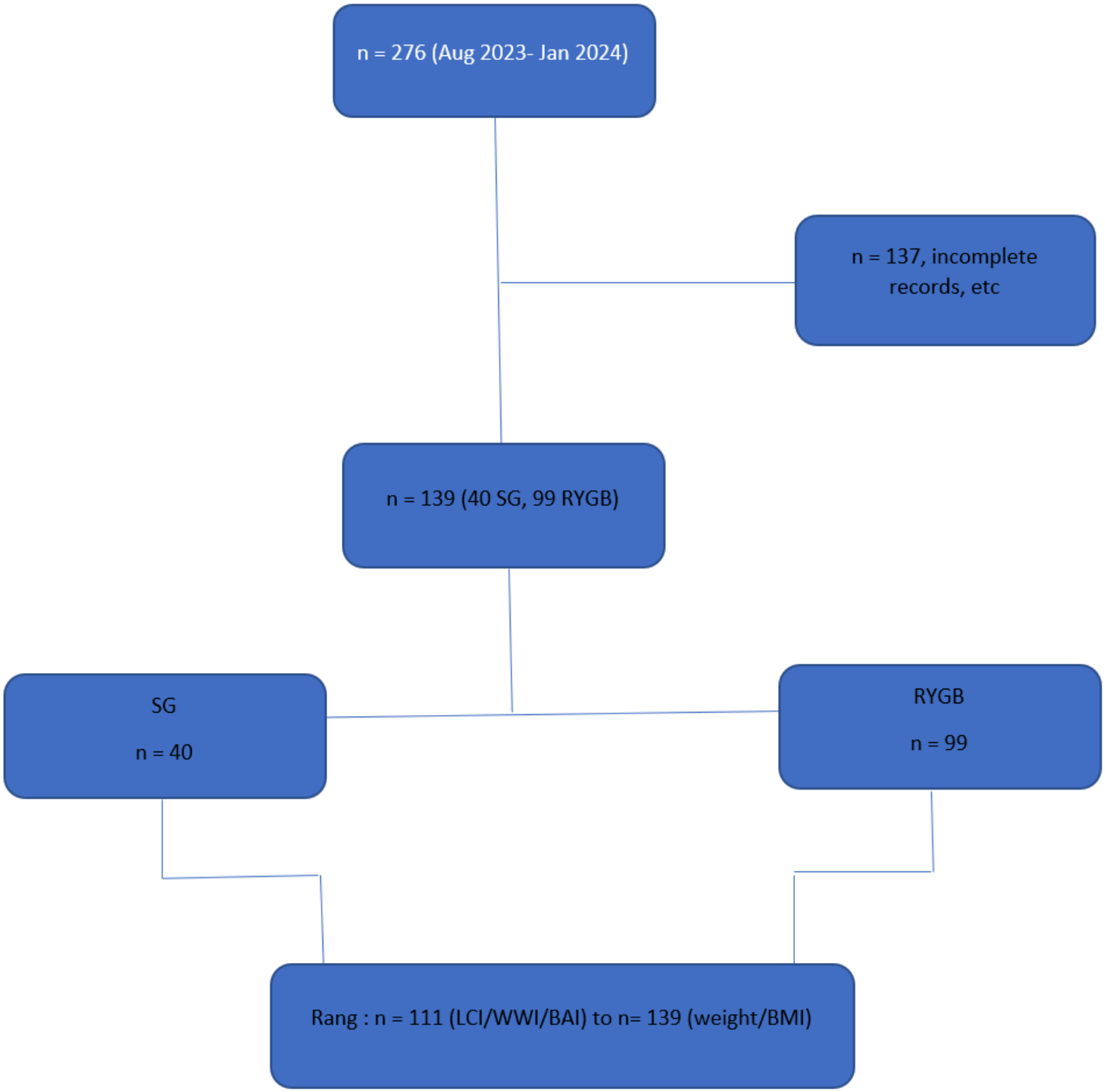

Figure 1

flowchart of study