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Three-Year Metabolic and Hormonal Outcomes Following Bariatric Surgery in Iraqi Patients: A Prospective Cohort Analysis Stratified by NAFLD Grade and Metabolic Syndrome

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النتائج الأيضية والهرمونية على مدى ثلاث سنوات عقب جراحات السمنة لدى المرضى العراقيين: تحليل دراسة أتراب استباقية مصنفة حسب درجة مرض الكبد الدهني غير الكحولي والمتلازمة الأيضية

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Abstract:

Background: Obesity-related metabolic disorders have become alarming in Iraq, but there is limited information on the long-term surgical outcomes in this population. Bariatric surgery especially Roux-en-Y gastric bypass (RYGB) and sleeve gastrectomy (SG) is the most long-lasting therapeutic choice in the treatment of morbid obesity and metabolic sequalae's. **Purpose**: To compare and contrast 3-year clinical and hormonal outcomes in RYGB and SG in Iraqi patients with a special focus on the predictive value of serial metabolic biomarkers and the moderating impact of baseline non-alcoholic fatty liver disease (NAFLD) severity and metabolic syndrome (MetS) status. **Methods**: A two-hospital tertiary referral prospective cohort study was carried out in Wasit, Iraq, where 240 patients (RYGB: n=120; SG: n=120) were recruited between January 2020 and December 2023. The main outcomes were percent excess weight loss (percent EWL), remission of type 2 diabetes mellitus (HbA1c <6.5% with no medication) and improvement of NAFLD (cap score reduction of at least 30% with FibroScan). At baseline, 12 months and 36 months, serial measurements of leptin, adiponectin, total ghrelin, active GLP-1, HOMA-IR, and QUICKI were measured. **Results**: At 36 months, RYGB produced significantly greater %EWL (77.1% ± 12.8 vs. 68.3% ± 14.5; p=0.004), T2DM remission (81.2% vs. 67.5%; p=0.025), and NAFLD improvement (85.0% vs. 71.7%; p=0.015) compared with SG. RYGB also yielded more pronounced hormonal remodeling, including greater adiponectin elevation (+5.5 vs. +3.4 µg/mL; p=0.003), leptin reduction (-34.5 vs. -27.6 ng/mL; p=0.005), and active GLP-1 augmentation (+17.8 vs. +9.1 pmol/L; p<0.001). An adiponectin/HOMA-IR greater than 0.75 composite index was predictive of T2DM remission following RYGB with 90% accuracy (AUC=0.86). There were no significant differences in major complication rates in between groups (8.3 vs. 5.8; p=0.45). **Conclusion**: RYGB has better metabolic and hormonal effects compared to SG in three years of follow-up of patients in Iraq. The adiponectin/ HOMA-IR composite index is a pragmatic, resource-efficient preoperative method to surgery triage and prognosis.

Keywords: Bariatric surgery; Sleeve gastrectomy; Gastric bypass; Type 2 diabetes; NAFLD; Adiponectin; HOMA-IR; Metabolic syndrome; Iraq; Precision surgery

الملخص

الخلفية :أصبحت الاضطرابات الأيضية المرتبطة بالسمنة تشكل تحدياً صحياً متزايداً في العراق، مع ندرة في البيانات المتعلقة بالنتائج الجراحية طويلة المدى لدى هذه الفئة من السكان .تُعد جراحات السمنة، ولاسيما تحويل مسار المعدة (RYGB) وتكميم المعدة(SG) ، الخيار العلاجي الأكثر استدامة للسمنة المفرطة وتبعاتها الأيضية .**أهداف الدراسة :**هدفت هذه الدراسة إلى مقارنة النتائج السريرية والهرمونية على مدى 3 سنوات بين جراحي (RYGB) و (SG)لدى المرضى العراقيين .وتركزت الدراسة بشكل خاص على القيمة التنبؤية للمؤشرات الحيوية الأيضية التسلسلية، والدور المعدل لشدة مرض الكبد الدهني غير الكحولي (NAFLD)وحالة المتلازمة الأيضية (MetS) عند خط الأساس .**المنهجية :**أُجريت دراسة أتراب استباقية في مستشفيين من مراكز الإحالة الثالثية في محافظة واسط، العراق، حيث شملت 240 مريضاً (RYGB: العدد=120؛ SG: العدد=120 (تم استقطابهم في الفترة ما بين يناير 2020 وديسمبر 2023 . تمثلت المخرجات الرئيسية في نسبة فقدان الوزن الزائد(EWL%) ، وهجوع داء السكري من النوع الثاني HbA1c <6.5% (بدون أدوية) ، وتحسن حالة الكبد الدهني (انخفاض درجة CAP بنسبة 30% على الأقل عبر تقنية .(FibroScan تم إجراء قياسات تسلسلية لكل من اللبتين، والأديبونيكتين، والغرلين الكلي، و GLP-1النشط، وHOMA-IR، و QUICKIعند خط الأساس، وبعد 12 و36 شهراً .**النتائج :** عند الشهر 36، حقق إجراء (RYGB) نتائج متفوقة بشكل ملحوظ مقارنة بـ (SG) في نسبة فقدان الوزن الزائد (12.8 ± 77.1%مقابل 68.3% ± 14.5؛p=0.004)، ومعدل هجوع السكري (81.2%مقابل 67.5%؛p=0.025)، وتحسن الكبد الدهني (85.0%مقابل 71.7%؛p=0.015) .كما أظهر (RYGB)إعادة تشكيل هرموني أكثر وضوحاً، شملت ارتفاعاً أكبر في الأديبونيكتين (5.5+مقابل +3.4 ميكروغرام/مل؛p=0.003)، وانخفاضاً أكبر في اللبتين (34.5-مقابل -27.6 نانوغرام/مل؛p=0.005)، وزيادة في GLP-1 النشط (+17.8 مقابل +9.1 بيكومول/لتر؛p<0.001) .وتبين أن المؤشر المركب (الأديبونيكتينHOMA-IR) الأعلى من 0.75 يمتلك قدرة تنبؤية لهجوع السكري بعد (RYGB) بدقة تصل إلى 90 .(AUC=0.86) %لم تظهر فروق ذات دلالة إحصائية في معدلات المضاعفات الكبرى بين المجموعتين 8.3(مقابل 5.8؛p=0.45). **الاستنتاج :**تتفوق عملية تحويل مسار المعدة (RYGB) على تكميم المعدة (SG) في تحقيق تأثيرات أيضية وهرمونية أفضل ومستدامة خلال ثلاث سنوات من المتابعة في العراق .يعد المؤشر المركب (الأديبونيكتينHOMA-IR/) وسيلة استباقية عملية وفعالة من حيث التكلفة للمفاضلة بين الجراحات والتنبؤ بالنتائج المستقبلية للمرضى .

الكلمات المفتاحية :جراحة السمنة؛ تكميم المعدة؛ تحويل مسار المعدة؛ داء السكري من النوع الثاني؛ الكبد الدهني غير الكحولي(NAFLD) ؛ الأديبونيكتين؛HOMA-IR ؛ المتلازمة الأيضية؛ العراق؛ الجراحة الدقيقة.

1. Introduction

In the last 20 years, obesity has evolved into a common clinical presentation to a nationwide epidemic of health in Iraq. According to national health surveys over one-third of the Iraq adults fit the obesity (BMI 30kg/m 2) requirement, and the prevalence exceeds 45 percent among those living in urban areas like Baghdad and Basra [1]. This growing burden can be explained by a number of intersecting factors; long-term socioeconomic instability, intense dietary westernization with a lot of refined carbohydrates and saturated fats, lack of physical activity, and disjointed healthcare delivery systems [2].

The striking feature of the Iraqi obesity phenotype is that it is often co-morbid with severe metabolism comorbidities. Co-occurring type 2 diabetes mellitus (T2DM), hypertension (systemic), and non-alcoholic fatty liver disease (NAFLD), put immense pressure on an already strained healthcare system [3]. Dietary counseling, behavioral modification, and pharmacotherapy as a method of conservative management of the disease has proven to be limited in terms of long-term success and the dropout rate is reported to be over 70 percent after 12 months of therapy [4].].

Bariatric surgery, including Roux-en-Y gastric bypass (RYGB) and sleeve gastrectomy (SG) has become the gold-standard procedure in persistent weight loss and elimination of obesity-related comorbidities. Multinational meta-analyses affirm similar decrease in body weight, T2DM remission in more than half of patients who do operate and considerable improvement in cardiovascular risk profiles [5, 6]. It is however, becoming apparent that not all populations have similar surgical outcomes; they depend on the genetic background, habitual diet, gut microbial composition and the preoperative metabolic phenotype of the patient [7].

Although this is known, there is no potential long-term study done in Iraq that looks at the molecular basis of metabolic restoration after bariatric surgery. This disparity has clinical implications: the hormonal dynamics of weight loss and comorbidity resolution in Iraqi patients may be learned and applied to patient selection and more individualized surgery planning.

To fill in this knowledge gap, the current study aimed to prospectively follow a cohort of 240 Iraqi patients following 36 months of RYGB or SG and systematic serial profiling of key metabolic hormones such as leptin, adiponectin, ghrelin, and active GLP-1. We did not simply aim to compare clinical efficacy of the two procedures but also to determine molecular signatures of metabolic recovery stratified by baseline MetS status and NAFLD severity, thus providing a basis of biomarker-based, personalized bariatric care in resource-constrained settings.

2. Materials and Methods

2.1 Study Design and Setting

This study was a prospective, cross-sectional, observational, and multicenter cohort study that was implemented at two university-affiliated tertiary hospitals in Wasit Governorate, central Iraq: Al-Zahraa Teaching Hospital (a 450-bed institution with an established Multidisciplinary Obesity Clinic since 2018) and Al-Karama Teaching Hospital (a The ethical approval by both institutions was given by their respective Institutional Review Boards (reference numbers: NZH/IRB/2020/017 and KTH/IRB/2020/009). All of the study participants signed an informed consent. It was designed and reported following the principles of the Declaration of Helsinki and STROBE reporting guidelines of an observational research.

2.2 Eligibility Criteria

They were eligible to enter the study when they were 18-65 years old with a BMI ≥40 kg/m 2 or ≥35kg/m 2 and at least one major obesity related comorbidity (T2DM, hypertension, NAFLD, or obstructive sleep apnea). Inclusion also entailed recorded failure of a systematic non-surgical weight management program at least six months in duration and permanent residence within 100 km of the research site to enable adherence to follow-up. The exclusion criteria included previous bariatric or upper gastrointestinal operation, active malignancy, advanced liver cirrhosis (Child-Pugh B/C), uncontrolled psychiatric disorders, pregnancy or pregnancy intention within 24 months following surgery, and refusal to give informed consent. The sample size was calculated based on a minimum clinically important difference of 8% of 105 patients per procedure with SD=15, alpha=0.05, power=0.80, which needed about 105 patients per arm. The number of patients enrolled (240) included a 15 percent attrition buffer. The 36-month follow-up protocol was done by all 240 participants.

2.3 Surgical Techniques

Four board-certified metabolic surgeons (IFSO and ISG-certified) carried out all the procedures laparoscopically with a history of over 100 successful bariatric surgeries. A 3236 Fr boulie was used to commence the sleeve gastrectomy, which commenced 4-6 cm above the pylorus and proceeded to the angle of His, and was reinforced with continuous oversewing the staple-line. In the case of RYGB, a 30-mL gastric pouch was made with a linear stapler; Roux limb was standardized at 150 cm and biliopancreatic limb at 100 cm, and gastrojejunal and jejojejunal anastomoses were created with a 45-mm linear stapler and reinforced with running sutures. Leak testing of methylene blue was regularly done at the end of every RYGB surgery.

The choice of the procedures was based on a structured shared decision-making model. Both operations were given standardized counseling to patients. The ultimate guidelines incorporated the patient preference, surgeon judgment on the basis of comorbidity profile, and anatomical factors. Patients having exceptionally advanced T2DM (HbA1c >9%) were more likely to be referred to RYGB; there was no randomization procedure.

2.4 Follow-up and Outcome Definitions

Preoperative and 1, 3, 6, 12-, 18-, 24-, and 36-months clinical assessments were done. Anthropometric data collection (weight, BMI, blood pressure) and fasting laboratory data (glucose, HbA1c, lipid profile, liver enzymes, creatinine, electrolytes) were collected at every visit. Transient elastography (FibroScan) with quantification of CAP score were done at baseline and 36 months. The remission of T2DM was determined as a HbA1c value of less than 6.5% and maintained over a minimum of three months without any glucose-lowering agents. Systolic BP less than 140 mmHg and diastolic BP less than 90 mmHg without antihypertensive agents were required to resolve hypertension. The improvement of NAFLD was determined as normalization of ALT (≤40 U/L) and a decrease in CAP score of 30 or more.

2.5 Biomarker Analysis

Baseline, 12 and 36 months Fasting venous blood samples (10 mL, EDTA tubes) were taken and stored at -80C, before batch analysis. The concentration of leptin, total ghrelin and adiponectin was determined using the Milliplex MAP Human Metabolic Hormone Panel, (Millipore, Germany). ELISA (Mercodia, Sweden) was used to measure active GLP-1 (7-36 amide) in samples collected in the presence of DPP-4 inhibitor. Chemiluminescent immunoassay (Siemens Advia Centaur) was used to determine fasting insulin. The calculation of HOMA-IR was [fasting insulin (mmol/L) × fasting glucose (mmol/L)/22.5]/ and QUICKI 1/ [log (fasting insulin mmol/L) + log (fasting glucose mg/dl)]. Each assay was done twice by one blinded lab worker.

2.6 Statistical Analysis

Analysis of data was done in SPSS Statistics v28 (IBM, USA) and R v4.3. Continuous variables are given as mean + standard deviation; comparisons between groups were by independent-samples t-tests or one-way ANOVA. Categorical variables are represented in form of frequency and percentages and compared using chi-square test or Fisher exact test. Biomarker change and clinical outcomes were correlated using Pearson. Kaplan-Meier curves were used to analyze time-to-event data, using log-rank tests. Binary logistic regression with multiple independent variables was used to determine predictors of T2DM remission. The diagnostic performance of adiponectin/HOMA-IR composite index was evaluated using receiver operating characteristic (ROC) analysis. All the tests were two-tailed; $p<0.05$ was taken to be statistically significant.

3. Results and Discussion

3.1 Study Population and Retention

Out of 312 patients screened in the period between January and March 2020, 240 (76.9) patients met all the requirements and followed the entire 36-month follow-up protocol had a retention rate that is relatively high as compared to other longitudinal studies that involve surgery taking

place in resource-constrained settings. Geographic relocation outside the 100-km catchment radius (n=45), inability to respond following repeated contact attempts (n=20) and voluntary withdrawal of serial blood sampling (n=7) were all sources of study attrition. Baseline demographic and metabolic features did not show any significant differences between completers and non-completers (all p.25), which assuages anxiety about selection bias. The soundness of primary outcome estimates was established by sensitivity analyses based on the use of the Last Observation Carried Forward and Multiple Imputation.

3.2 Demographic and Clinical Profile: Baseline.

The summary of baseline characteristics between the two surgical groups is found in Table 1. The patient population (83.8% female) was representative of the epidemiology of bariatric surgery in the area. Mean age was 38.5 ± 9.3 years and mean BMI was 45.1 ± 6.0 kg/m². Prevalence of T2DM was 57.1%, hypertension 53.3%, and NAFLD (CAP >248 dB/m) 89.6%. Baseline BMI had a slight difference in favor of the RYGB group (45.9 vs. 44.3 kg/m 2; p=0.03), but the rest of the characteristics were similar. The patients had 165 patients diagnosed with metabolic syndrome based on the criteria of the IDF (68.8%).

Table 1. Baseline Demographic and Clinical Characteristics Stratified by Surgical Procedure

Variable	Total Cohort (n=240)	Gastric Bypass (n=120)	Sleeve Gastrectomy (n=120)
Demographic Data			
Age, mean ± SD (years)	38.5 ± 9.3	39.2 ± 8.9	37.8 ± 9.6
Female sex, n (%)	201 (83.8)	102 (85.0)	99 (82.5)
Anthropometric Measure			
Body mass index, mean ± SD (kg/m²)	45.1 ± 6.0	45.9 ± 5.7	44.3 ± 6.2†
Comorbid Conditions			
Type 2 diabetes, n (%)	137 (57.1)	72 (60.0)	65 (54.2)
Hypertension, n (%)	128 (53.3)	66 (55.0)	62 (51.7)
NAFLD, n (%)	215 (89.6)	108 (90.0)	107 (89.2)
Metabolic syndrome, n (%)	165 (68.8)	—	—

Notes:

Data are presented as mean ± SD or number (percentage).

† Statistically significant difference between groups (p = 0.03); all other comparisons were not significant.

3.3 Weight Loss Outcomes

The two procedures yielded clinically significant weight loss through the course of observation. Both groups had a biphasic temporal pattern with rapid loss the first 12 months followed by a relative plateau with partial weight regain between months 12 and 36. During the first stage, RYGB patients had a mean percent weight loss of 61.8% with a SD of 11.2 which was much higher than 53.5% SD12.7 of the post-SG. The recovery phase was stronger in the SG group with a mean regain of 4.9 percent of maximal loss as opposed to 3.3 percent after RYGB (p=0.02).

At the primary 36-month endpoint, RYGB demonstrated substantially superior weight loss outcomes: %EWL of 77.1% ± 12.8 versus 68.3% ± 14.5 (p=0.004), and total weight loss (%TWL) of 34.8% ± 5.6 versus 30.9% ± 6.1 (p=0.002). It seems that the longer-lasting hormonal reprogramming, especially, 3.1-fold higher active GLP-1 levels at baseline versus 36 months in the RYGB group than in SG (p<0.001) supports the durability of its weight loss benefit. This enhanced incretin secretion is probably at the heart of the prolonged appetite control especially in a population that is accustomed to high-glycemic nutritional habits.

3.4 Resolution of Comorbidity at 36 Months.

The results of the three main comorbidity endpoints are shown in table 2. T2DM remission occurred in 81.2% (56/69) of RYGB patients versus 67.5% (46/68) of SG patients (p=0.025). The Kaplan-Meier analysis showed that metabolic recovery was significantly earlier in the RYGB group where the median time to remission was 6.4 months as opposed to 9.1 months in the SG group (log-rank p=0.01). Of specific interest is the increased remission rate in spite of an average diabetes length of 5.1 years, which could be explained by a greater level of residual beta-cell plasticity among Iraqi patients which could be due to reduced exposure to ultra-processed food and fructose compared to Western patients.

The hypothesis that RYGB's ability to improve hepatic steatosis may rely on modulation of bile acid circulation and FXR/TGR5 hepatic signaling pathways was supported by noting NAFLD improvement in 85.0% of RYGB recipients compared to 71.7% of SG recipients (p=0.015). There was a tendency toward higher rates of hypertension resolution with RYGB (73.6% vs. 64.3) but did not reach significance (p=0.052); resolution was highly correlated with the degree of weight loss (r=-0.66, p<0.001), indicating that hypertension improvement in this group is largely weight-related.

Table 2. Comparative Three-Year Outcomes Following Bariatric Procedures

Outcome Measure	Gastric Bypass (RYGB)	Sleeve Gastrectomy (SG)	Between-Group Difference
Weight Reduction Outcomes			
Excess weight loss (%)	77.1 ± 12.8	68.3 ± 14.5	Significant (p = 0.004)
Total weight loss (%)	34.8 ± 5.6	30.9 ± 6.1	Significant (p = 0.002)
Metabolic Outcomes			
Diabetes remission, n/N (%)	56/69 (81.2)	46/68 (67.5)	Significant (p = 0.025)
NAFLD improvement, n/N (%)	85/100 (85.0)	71/99 (71.7)	Significant (p = 0.015)
Hypertension resolution, n/N (%)	47/64 (73.6)	45/70 (64.3)	Not significant (p = 0.052)

Notes:

Values are expressed as mean ± standard deviation or proportion (n/N, %). Statistical significance was defined as p < 0.05. RYGB = Roux-en-Y gastric bypass; SG = sleeve gastrectomy; %EWL = percent excess weight loss; %TWL = percent total weight loss; T2DM = type 2 diabetes mellitus; NAFLD = non-alcoholic fatty liver disease.

3.5 Metabolic Biomarker Dynamics

Serial hormonal profiling also demonstrated that both procedures had a high degree of directionally concordant changes in all the measured biomarkers with RYGB having stronger changes. Table 3 indicates that a significantly higher increase in adiponectin (+5.5 vs. +3.4 µg/mL; p=0.003) an adipokine which enhances insulin sensitivity via the AMPK and PPAR-g pathway was linked with RYGB. The decrease in leptin was also more pronounced after RYGB (-34.5 vs. -27.6 ng/mL; p=0.005) in line with a more complete re-setting of the central adipostat with increased fat mass loss. The most pronounced difference between the groups was active GLP-1 augmentation (+17.8 vs. +9.1 pmol/L; p<0.001), which has mechanistic implications

due to the dual mechanism of action of GLP-1, namely, the stimulation of pancreatic insulin secretion and central satiety.

In terms of insulin resistance indicators, RYGB had a greater decrease in HOMA-IR (-4.7 vs. -3.7; p=0.018). The inverse relationship between adiponectin and changes in HOMA-IR (r=-0.72, p<0.001) was pronounced throughout the cohort, which further supports the idea that adiponectin is the center of mediating post-surgical insulin sensitivity recovery. The alteration in the percent of EWL was strongly associated with the alterations in Adiponectin (r=0.68) and HOMA-IR (r= -0.71) but T2DM remission was most strongly correlated with 8GLP-1 (r=0.64). A notable observation in the region was that the GLP-1 incretin response after RYGB (3.1-fold increase) was larger than magnitudes traditionally reported in cohorts in the West (2.02.5-fold). This can be an indicator of a higher level of suppression of baseline GLP-1 due to the long-term high-carbohydrate dietary habits in the Iraqi population, which causes a larger hormonal rebound following the nutrient rerouting with the Roux limb.

Table 3. Changes in Metabolic Biomarkers Over 36 Months After Bariatric Surgery

Biomarker	Baseline (RYGB)	36 Months (RYGB)	Δ Change (RYGB)	Baseline (SG)	36 Months (SG)	Δ Change (SG)	Between-Group *p*-value
Leptin (ng/mL)	47.8 ± 15.1	13.3 ± 4.3	−34.5	45.2 ± 13.9	17.6 ± 5.1	−27.6	0.005
Ghrelin (µg/mL)	618 ± 178	883 ± 205	+265	612 ± 173	732 ± 185	+120	0.002
Adiponectin (µg/mL)	4.2 ± 1.1	9.7 ± 2.1	+5.5	4.4 ± 1.2	7.8 ± 1.8	+3.4	0.003
Active GLP-1 (pmol/L)	8.3 ± 3.0	26.1 ± 6.0	+17.8	8.6 ± 2.8	17.7 ± 4.6	+9.1	<0.001
HOMA-IR	6.7 ± 2.3	2.0 ± 0.6	−4.7	6.4 ± 2.1	2.7 ± 0.8	−3.7	0.018

Notes:

Values are presented as mean ± standard deviation. Δ change represents the absolute difference from baseline to 36 months.
All within-group changes were statistically significant (p < 0.01).
RYGB = Roux-en-Y gastric bypass; SG = sleeve gastrectomy; GLP-1 = glucagon-like peptide-1; HOMA-IR = homeostatic model assessment of insulin resistance.

3.6 Predictors of T2DM Remission

Five independent predictors of T2DM remission at 36 months were found by multivariate logistic regression (Table 4). The most significant predictor was the magnitude of the weight loss (encompassing 70% and above; OR 4.05, 95% CI 2.15763; p<0.001), which demonstrates the key role of the weight loss magnitude in metabolic recovery. An HbA1c preoperative of less than 8.5% (OR 2.98; p=0.001), a diabetes duration of less than five years (OR 2.39; p=0.007), the RYGB surgery per se (OR 2.08; p=0.028), and preoperative adiponectin/HOMA-IR composite index

These results have immediate clinical implications. A patient with RYGB, a HbA1c reading of 7.8, and a diabetes length of four years with >70 percent EWL has an approximate likelihood of remission of circa 88 percent which allows significant preoperative prognostication and counseling of the patient.

Table 4. Independent Predictors of Type 2 Diabetes Remission at 36 Months: Multivariable Analysis

Variable	Effect Estimate (OR, 95% CI)	Statistical Significance
Surgical procedure (RYGB vs. SG)	2.08 (1.09–3.97)	$p = 0.028$
Baseline HbA1c < 8.5%	2.98 (1.58–5.62)	$p < 0.001$
Diabetes duration < 5 years	2.39 (1.27–4.51)	$p = 0.007$
Excess weight loss > 70%	4.05 (2.15–7.63)	$p < 0.001$
Adiponectin/HOMA-IR index > 0.75	3.87 (2.01–7.45)	$p < 0.001$

Notes:
Odds ratios (ORs) are derived from multivariate logistic regression analysis. Confidence intervals (CI) are reported at the 95% level. Statistical significance was defined as p < 0.05. RYGB = Roux-en-Y gastric bypass; SG = sleeve gastrectomy; HbA1c = glycated hemoglobin; HOMA-IR = homeostatic model assessment of insulin resistance.

3.7 Composite Biomarker Index for Outcome Prediction

A new composite preoperative index of adiponectin (µg/mL)/ HOMAIR was assessed based on its capacity to predict T2DM remission after RYGB.B. The overall remission rate in patients with a baseline index over 0.75 was 90% compared to 66% in patients with a baseline index at or below this level (p<0.001). ROC analysis revealed an AUC of 0.86 (95% CI: 0.79 0.93), sensitivity of 83, and specificity of 77, which is better than either of the biomarkers alone (adiponectin alone: AUC 0.78, HOMA-IR alone: AUC 0.80).

This index has a significant practical importance to the healthcare setting with limited resources. Both constituent assays adiponectin quantification and fasting insulin/glucose determination to derive HOMA-IR are generally easily available and relatively cheap and do not need special infrastructure.e. This makes the index a realistic triage tool to determine patients who are most likely to experience T2DM remission to guide the assignment of surgical resources in an equitable way based on resources.

3.8 Subgroup Analysis: NAFLD Severity and Metabolic Syndrome.

Baseline stratification based on the severity of steatosis disclosed a significant difference response to surgery. For patients with mild (CAP 249–279 dB/m) or moderate (CAP 280–309 dB/m) NAFLD, improvement rates were equivalent between procedures (mild: 95.0% vs. 87.5%, p=0.25; moderate: 88.9% vs. 88.1%, p=0.89). Nevertheless, RYGB showed significantly better results in patients with high-baseline steatosis (CAP ≥310 dB/m) (62.9 vs. 40.5; p=0.04) indicating that its distinct effect of bile acid metabolism and FXR/TGR5 hepatic signaling gains disproportionate relevance in challenging patients with advanced hepatic lipid deposition

RYGB produced much greater improvements in all hormone parameters in patients with baseline MetS (n=165): ΔHOMA-IR = -5.6 vs -3.0 (p=0.002), ΔAdiponectin = +6.1 vs +4.0 µg/mL (p=0.004), and ΔGLP-1 = +19.5 vs Importantly, T2DM rates in MetS-positive patients after RYGB (80.5%), were no longer significantly different than those of MetS-negative patients (82.8; p=0.72), which means that RYGB is effective in counteracting the negative prognostic effect of metabolic syndrome has significant implications in preoperative risk assessment among Iraqi patients..

3.9 Ghrelin Dynamics and Weight Regain.

Both the procedures were linked to paradoxical increase of total ghrelin at 36 months (RYGB: +265 µg/mL; SG: +120 µg/mL; p=0.002 between groups). Although ghrelin is known to be orexigenic, this increase was not associated with weight regain in the RYGB group (r= -0.10,

p=0.22) presumably due to the highly increased GLP-1 and PYY levels that occur after RYGB and mask the appetite-stimulating action of ghrelin. Conversely, ghrelin increase in the SG group showed a significant positive correlation with late weight gain (r=0.32, p=0.03), indicating an incomplete neurohormonal adaptation as a possible cause of the increased weight recidivism in this arm.

3.10. Nutritional Complications and Safety Profile

The incidences of major complications (Clavien-Dindo ≥III) were 8.3 percent in the RYGB group and 5.8 percent in the SG group (p=0.45) and no deaths were reported in both groups. There was one anastomotic leak and one marginal ulcer post-RYGB, and one staple-line bleed and one leak post-SG; all treated laparoscopically. Procedure specific late complications were marginal ulceration (4.2) and internal herniation (1.7): RYGB group had most procedure specific complications, whereas GERD needing medical escalation (1.7) and sleeve stenosis (0.8) were more typical of SG. Multivariate Cox regression found independent predictors of major complications to be baseline HbA1c >8.5% and age >50 years not procedure type.s.

As might be expected due to the presence of RYGB malabsorptive component, micronutrient deficiencies were even more common at 36 months in this group: vitamin B12 deficiency (27.5% vs. 9.2%; p=0.001), iron deficiency by ferritin (35.0% vs. 18.3%; p=0.002 All of these deficiencies did not lead to the irreversible neurological or hematological consequences, which was due to compliance with protocol-based supplementation (monthly intramuscular B12 1000 µg, daily elemental iron 65 mg, daily vitamin D3 5000 IU in RYGB patients). These results highlight how the Iraqi healthcare system needs institutionalized and nationally insured post-bariatric nutritional protocols.

4. Conclusion

This is the first prospective three-year cohort study to involve serial metabolic biomarker profiling in Iraq to provide strong evidence showing that RYGB is better and more sustained metabolic remodeling than SG on a variety of clinically relevant outcomes, such as weight loss, T2DM and NAFLD remission, as well as hormonal reconstitution.n. Importantly, such benefits are preserved even in patients who have the most problematic baseline profiles, such as patients with severe NAFLD or with complete metabolic syndrome.

This work results in the adiponectin/HOMA-IR composite index (cutoff >0.75) as a practical, low cost, and highly predictive preoperative biomarker applicable in the face of resource limitation to guide surgical decision-making and patient counseling. The similarity of the safety profiles of the two procedures, as well as the lack of mortality, indicate that advanced metabolic surgery may be provided safely in the Iraqi public health care system in the presence of a standardized protocol, multidisciplinary team, and strict postoperative monitoring.

Future studies would benefit in focusing on prospective dietary and physical activity tracking to further clarify the mediating effect of surgical success, and multi-regional Iraqi studies are justified to confirm these results with ethnically and culturally diverse subpopulations. Causal inferences made based on this observational platform would be further enhanced by randomized controlled trials.

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