Diabetes Remission and Weight Loss Outcomes Following Bariatric Surgery: A Retrospective Cohort Study from Bahrain

Najla Shamsi[1]*, Heba Mohamed Jasim Hamada[2], Alexa Lulu Mcguinness[3], Aseel Abdulmenem Abualsel[3], Gana Ahmed Sharafeldin[3], Kawthar Ali Alasmawi[3], Zahra Mahdi[3], Khawla F. Ali[4], Rawa Alsayegh[5], Shatha Fuad Mohamed[6], Raja Eid[7], John Flood[8] and Abdulmenem Abualsel[9]

[1]Consultant Family Physician, Diabetologist, Clinical Educator in Department of Medicine, RCSI Medical University of Bahrain

[2]Medical Doctor, M.D. MSc.medSci

[3]Medical Student, RCSI Medical University of Bahrain

[4]Clinical Senior Lecturer, Department of Medicine, RCSI Medical University of Bahrain

[5]Clinical Educator in Department of Medicine, RCSI Medical University of Bahrain

[6]Medical Doctor, MB, BCh, BAO (Hons), University Hospitals of Leicester NHS Trust, United Kingdom

[7]Consultant General Surgery, Governmental hospitals, Kingdom of Bahrain. Clinical Senior Lecturer, Department of Surgery RCSI Medical University of Bahrain

[8]Head of Department of Medicine, Department of Medicine, RCSI Medical University of Bahrain

[9]Consultant General Surgery and bariatric surgery, Department of Surgery, King Hamad University Hospital- Bahrain-RMS

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*Corresponding author: nshamsi@rcsi.com

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Abstract

Objectives: Obesity is a significant public health challenge in Bahrain. It is a well-established risk factor for a spectrum of metabolic disorders, including type 2 diabetes mellitus (T2DM), hypertension and dyslipidemia. These conditions contribute to increased morbidity and mortality, as well as substantial healthcare burdens. This retrospective cohort study evaluates metabolic outcomes following bariatric surgery in 1,291 Bahraini patients from 2016–2023.

Methods: A single-center retrospective cohort analysis was conducted on 1,291 patients who underwent bariatric surgery at King Hamad University Hospital between January 2016 and December 2023. Statistical analyses included paired t-tests, Chi-square tests, and logistic regression.

Results: Both restrictive and malabsorptive bariatric procedures resulted in significant weight loss (~26%) and excess weight loss (~63%). Diabetes remission occurred in 70.9%, with Sleeve gastrectomy (SG) achieving a higher remission rate (76.3%) than Gastric Bypass (63.6%), though the difference was not statistically significant. Predictors of remission included younger age, higher preoperative C-peptide, and absence of insulin therapy.

Conclusions: Bariatric surgery, particularly SG, is an effective intervention for weight reduction and metabolic improvement in the Bahraini population. Despite comparable diabetes remission rates between SG and Gastric Bypass, SG's procedural simplicity and lower complication risk may provide a clinically advantagrous risk-benefit

profile.Sustained metabolic benefits require long-term follow-up, adherence to lifestyle modifications, and individualized patient selection to optimize outcomes.

Keywords: Metabolic Surgery; Bariatric Surgery; Sleeve Gastrectomy; Gastric Bypass; Obesity; Diabetes Remission; Metabolic Disorders; Bahrain.

Introduction

Obesity is a growing and critical public health issue in Bahrain. Recent national surveys indicating that approximately 42.8% of the population is classified as obese and 18.4% of nationals diagnosed with type 2 diabetes mellitus (T2DM).[1] This rising prevalence has not only strained healthcare resources but also contributed to rising rates ofrelated metabolic disorders, including hypertension, dyslipidemia, and metabolic dysfunction-associated steatotic liver disease (MASLD).[2-6]

Bariatric surgery has proven to be one of the most effective long-term interventions for obesity and its metabolic complications. Over the last decade, clinical guidelines increasingly acknowledge the metabolic benefits of bariatric procedures, particularly in promoting diabetes remission and improving cardiovascular risk profiles.[7-11] As a result, the terminology has evolved from "bariatric" to "metabolic surgery," reflecting the broader systemic effects beyond weight loss.[9,10] Procedures such as sleeve gastrectomy (SG) and gastric bypass (including Roux-en-Y and one-anastomosis techniques) offer substantial benefits, but differ in their risk profiles, nutritional impacts, and long-term efficacy. While malabsorptive procedures often yield superior weight loss and glycemic outcomes, they are associated with higher rates of nutrient deficiencies and long-term complications. In contrast, SG is technically simpler and increasingly preferred for its lower complication rates, despite some variability in long-term outcomes.[12]

In Bahrain, demand for bariatric surgery has surged, but research on long-term metabolic outcomes in the local population remains limited. Existing studies have largely focused on short-term weight reduction, perioperative safety, and patient-reported outcomes, while comprehensive assessments of metabolic remission, nutritional stability, and predictive factors over extended follow-up periods are scarce.[13-18]

This study addresses that gap by evaluating the long-term effects of bariatric surgery—specifically restrictive and malabsorptive procedures—on metabolic health in the Bahraini population. The primary focus is on diabetes remission, alongside secondary outcomes including weight loss, blood pressure control, lipid profile changes, and nutritional markers. Additionally, this analysis explores predictors of sustained metabolic improvement, aiming to inform clinical decision-making and individualized patient care.

By providing evidence from over 1,200 patients treated at a single tertiary center over eight years, this study contributes valuable regional data and offers insights into optimizing metabolic surgery pathways in the Gulf region.

Methods

The study included all patients who underwent one of the Six types of bariatric surgery at the Bariatric Unit of King Hamad University Hospital in Bahrain between January 2016 and December 2023. The types of surgeries included were as follows: Sleeve Gastrectomy (SG), Roux-en-Y Gastric Bypass (RYGB), One-Anastomosis (Mini) Gastric Bypass (OAGB), Biliopancreatic Diversion (BPD), Single Anastomosis Duodenal-Ileal Bypass with Sleeve Gastrectomy (SADI-S).

Inclusion Criteria:

1. Patients who underwent any type of bariatric surgery (e.g., sleeve gastrectomy, Roux-en-Y gastric bypass, one anastomosis gastric bypass) during the study period.
2. Availability of complete baseline (preoperative) clinical and laboratory data.

3. Minimum of 6 months of postoperative follow-up data available at the time of analysis.

4. At least one postoperative follow-up conducted a minimum of 6 months prior to the data collection period (i.e. prior to June 2023)

5. No restrictions were applied regarding age, BMI, or presence of chronic comorbidities.

Exclusion criteria:

1. Patients who underwent non-surgical weight loss interventions or bariatric devices (e.g., intragastric balloon, gastric banding).

2. Patients with missing most of the postoperative data.

We retrospectively collected data from the Electronic Medical Records (EMR) system. The dataset included demographic information, baseline clinical characteristics, the type of bariatric procedure performed, and postoperative follow-up data. We assessed primary outcomes such as weight reduction, diabetes remission, and predictors of diabetes remission. For this purpose, we extracted relevant variables including age, sex, BMI, HbA1c, C-peptide levels, and use of insulin or oral hypoglycemic agents. We also collected secondary variables related to comorbidities (e.g., hypertension, dyslipidemia) and laboratory profiles (e.g., liver enzymes, lipid panels, and renal markers) to enable a comprehensive evaluation of metabolic outcomes.

Postoperative follow-up adhered to institutional protocols, with visits typically scheduled at 1, 3, 6, and 12 months, and annually thereafter. However, the actual timing and frequency of follow-up varied depending on clinical indication and patient adherence. For the purposes of this study, only patients with a minimum of 6 months of postoperative follow-up were included in the analysis. At each follow-up visit, weight, BMI, comorbidity status, medication use, and relevant laboratory investigations (including HbA1c, fasting glucose, lipid profile, liver enzymes, and renal function tests) were documented. When multiple follow-up visits were available, the most recent values within the eligible follow-up period were used for analysis.

We analyzed the data using SPSS version 27. We expressed continuous variables as means ± standard deviations (SD) and compared them using paired-sample t-tests. We summarized categorical variables as frequencies and percentages and assessed them using chi-square tests. To identify predictors of diabetes remission, we performed binary logistic regression, adjusting for variables including age, BMI, percentage of weight loss, preoperative C-peptide, HbA1c, and insulin use. We considered a p-value of <0.05 statistically significant.

Results

A total of 1,291 patients who underwent bariatric surgery at our center between January 2016 and December 2023 were included. The majority were between 18 and 64 years of age (mean 38.7 ± 10.9 years), and 64.8% were female. The average preoperative weight was 124 ± 27 kg, and the mean BMI was 45.12 ± 8.27 kg/m², with 72.7% of patients classified as morbidly obese. Of the total cohort, 15 patients (1.2%) had a BMI below 30 kg/m² at the time of surgery. These cases met approval criteria due to persistent type 2 diabetes and supported by emerging evidence—such as the DiRECT trial—demonstrating that substantial diabetes remission can be achieved through modest weight loss even in non-obese individuals. Subgroup analysis was not conducted due to insufficient sample size.[19] Sleeve gastrectomy (SG) was the most frequently performed procedure (74%), followed by one-anastomosis gastric bypass (20%). A small subset (3.4%) underwent revision surgery. The mean follow-up period differed significantly by surgical type, with SG patients followed for 2.27 ± 2.14 years compared to 1.63 ± 1.66 years for those undergoing OAGB (p < 0.001).

Table 1: Baseline demographic characteristics of patients (Total = 1291).

Characteristics		**n (%)**
Age in years	<18	5 (0.4)
	18-64	1263 (97.8)

		≥65	23 (1.8)
		Mean ± SD	38.7 ± 10.9
Gender		Male	454 (35.2)
		Female	837 (64.8)
Weight in kg[1]		Mean ± SD	124 ± 27
BMI[2]		Underweight	0 (0)
		Normal	6 (0.5)
		Overweight	9 (0.7)
		Mild Obesity	69 (5.4)
		Moderate Obesity	266 (20.7)
		Morbid Obesity	932 (72.7)
		Mean ± SD	45.12 ± 8.27
Type of surgery	SG[3]	SG	955 (74)
		NSG	49 (3.8)
	Gastric Bypass[4]	OAGB	258 (20)
		RYGB	23 (1.8)
		BPD	4 (0.3)
		SG+TB	2 (0.2)
Revision[5]		Yes	44 (3.4)
		No	1247 (96.6)
Type of revision		SG	29 (50.9)
		RYGB	7 (12.3)
		OAGB	18 (31.6)
		BPD	0 (0)
		NSG	1 (1.8)
		SG+TB	2 (3.5)

1. Number of missing = 7; 2. Body Mass Index (BMI) Number of missing = 9.;3. Sleeve Gastrectomy (SG) = Restrictive surgeries combined. 4. Gastric Bypass = Malabsorptive surgeries combined. 5. Number of patients whose current surgery is a revision = 23 and number of patients who undergone revision = 21.

Postoperative evaluation revealed significant clinical and metabolic improvements. Patients with missing postoperative data were excluded from the final analysis to ensure the accuracy and completeness of outcome assessments. Mean weight decreased from 124 ± 27.0 kg to 90.8 ± 25.6 kg ($p < 0.001$), and BMI decreased from 45.1 ± 8.2 to 33.1 ± 8.4 kg/m² ($p < 0.001$). Systolic and diastolic blood pressure also declined significantly (128.4 ± 13.8 to 119.2 ± 12.9 mmHg and 75.3 ± 10.5 to 71.6 ± 10.0 mmHg, respectively; $p < 0.001$). Glycemic parameters improved, with fasting blood glucose falling from 6.4 ± 2.3 to 5.1 ± 1.4 mmol/L and HbA1c from 6.2 ± 1.6% to 5.4 ± 0.9% (both $p < 0.001$). C-peptide levels decreased from 2.5 ± 1.3 to 1.5 ± 0.8 ng/ml ($p < 0.001$), suggesting enhanced insulin sensitivity. Additionally, we observed significant reductionsin total cholesterol, LDL, triglycerides, and uric acid levels, while HDL increased significantly ($p < 0.001$ for all).

Table 2: Difference in the mean of study parameters between pre and post bariatric operation.

Parameters	**N**	**Pre-operation Mean ± SD**	**Post-operation Mean ± SD**	**% change**	**Mean difference (95% CI)**	**P-value**
Systolic blood pressure	1251	128.35 ± 13.8	119.24 ± 12.89	-7.1	-9.11 (-10.16 to -8.06)	<0.001**
Diastolic blood pressure	1251	75.26 ± 10.47	71.56 ± 10.01	-4.92	-3.70 (-4.50 to -2.90)	<0.001**
Weight	1263	123.89 ± 26.96	90.84 ± 25.63	-26.68	-33.05 (-35.10 to -31.00)	<0.001**
Height	1279	1.65 ± 0.09	1.65 ± 0.09	0	0.00 (-0.01 to 0.01)	0.528
BMI	1260	45.09 ± 8.24	33.05 ± 8.36	-26.7	-12.04 (-12.69 to -11.39)	<0.001**

C-peptide (ng/ml)	364	2.54 ± 1.32	1.53 ± 0.8	-39.76	-1.01 (-1.17 to -0.85)	<0.001**
Urea (mmol/l)	632	4.5 ± 1.56	4.42 ± 2.8	-1.78	-0.08 (-0.33 to 0.17)	0.424
Uric Acid (μmol/l)	475	341.92 ± 96.48	300.09 ± 89.59	-12.23	-41.83 (-53.67 to -29.99)	<0.001**
Creatinine (μmol/l)	631	66.87 ± 18.07	65.04 ± 32.39	-2.74	-1.83 (-4.72 to 1.06)	0.061
Calcium (mmol/l)	529	2.3 ± 0.13	2.29 ± 0.14	-0.43	-0.01 (-0.03 to 0.01)	0.069
Magnesium (mmol/l)	441	0.8 ± 0.08	0.8 ± 0.08	0	0.00 (-0.01 to 0.01)	0.806
Albumin (g/l)	610	39.83 ± 4.84	40.94 ± 4.56	2.79	1.11 (0.58 to 1.64)	<0.001**
Alkaline Phosphatase (ALP) (U/l)	574	81.87 ± 23.18	78.92 ± 80.81	-3.6	-2.95 (-9.83 to 3.93)	0.377
Alanine transaminase (ALT) (U/l)	575	38.11 ± 28.71	30.61 ± 104.12	-19.68	-7.50 (-16.33 to 1.33)	0.092
Gamma-glutamyl Transferase (GGT) (U/l)	547	44.76 ± 42.11	26.6 ± 41.17	-40.57	-18.16 (-23.10 to -13.22)	<0.001**
Aspartate aminotransferase (AST) (U/l)	527	22.9 ± 14.16	27.23 ± 78.69	18.91	4.33 (-2.50 to 11.16)	0.214
Cholesterol (mmol/l)	479	4.91 ± 1.03	4.6 ± 0.91	-6.31	-0.31 (-0.43 to -0.19)	<0.001**
Triglyceride (mmol/l)	469	1.52 ± 1.36	0.98 ± 0.62	-35.53	-0.54 (-0.68 to -0.40)	<0.001**
Parathyroid hormone (PTH) (pg/ml)	350	83.91 ± 65.88	75.71 ± 62.07	-9.77	–8.20 (–17.68 to 1.28)	0.017
Thyroid stimulation hormone (TSH) (μIU/ml)	518	2.67 ± 3.5	2.33 ± 2.51	-12.73	-0.34 (-0.71 to 0.03)	0.050
Hemoglobin A1c (HbA1c) (%)	481	6.24 ± 1.56	5.36 ± 0.87	-14.1	-0.88 (-1.04 to -0.72)	<0.001**
Iron (μmol/l)	510	12.32 ± 6.34	14.91 ± 8.8	21.02	2.59 (1.65 to 3.53)	<0.001**
C-reactice protein (C-RP) (mg/l)	462	12.59 ± 13.99	10.2 ± 28.31	-18.98	-2.39 (-5.27 to 0.49)	0.097
Vitamin B-12 (pg/ml)	501	392.31± 178.16	475.11 ± 252	21.11	82.80 (55.78 to 109.82)	<0.001**
Very low density lipoprotein (VLDL) (mmol/l)	416	0.3 ± 0.31	0.19 ± 0.09	-36.67	-0.11 (-0.14 to -0.08)	<0.001**
Total iron binding capacity (TIBC) (μmol/l)	444	60.88 ± 8.98	57.55 ± 10.38	-5.47	–3.33 (–4.61 to –2.05)	<0.001**
Serum ferritin (ng/ml)	433	88.98 ± 106.97	93.41 ± 137.42	4.98	4.43 (-11.97 to 20.83)	0.478
Low density lipoprotein (LDL) (mmol/l)	466	3.33 ± 0.91	2.91 ± 0.84	-12.61	-0.42 (-0.53 to -0.31)	<0.001**
High density lipoprotein (HDL) (mmol/l)	467	1.22 ± 0.34	1.45 ± 0.38	18.85	0.23 (0.18 to 0.28)	<0.001**
Fasting blood sugar (FBS) (mmol/l)	414	6.41 ± 2.3	5.11 ± 1.35	-20.28	-1.30 (-1.56 to -1.04)	<0.001**
Vitamin D (ng/ml)	509	17.53 ± 11.14	24.78 ± 12.69	41.36	7.25 (5.78 to 8.72)	<0.001**
Hemoglobin (g/dl)	830	13.29 ± 1.62	12.81 ± 1.64	-3.61	-0.48 (-0.64 to -0.32)	<0.001**
Platelets (x10^9/l)	798	305.62 ± 72.49	271.37 ± 74.71	-11.21	-34.25 (-41.47 to -27.03)	<0.001**

*P-values were computed by using paired-samples t-test; **Significant at 0.01 level. SD: Standard Deviation.*

Changes in bone and nutritional markers were variable. Parathyroid hormone (PTH) declined from 83.9 ± 65.9 to 75.7 ± 62.1 pg/ml ($p < 0.001$), possibly indicating favorable shift in bone remodeling markers. However, serum calcium and magnesium remained stable ($p = 0.069$ and $p = 0.806$, respectively). Although total iron-binding capacity significantly decreased (60.9 ± 9.0 to 57.6 ± 10.4 μmol/L, $p < 0.001$), serum ferritin levels showed no significant change. Vitamin B12 and Vitamin D levels improved significantly postoperatively (392.3 ± 178.2 to 475.1 ± 252.0 pg/ml and 17.5 ± 11.1 to 24.8 ± 12.7 ng/ml, respectively; $p < 0.001$ for both), indicating effective supplementation and nutritional support. CRP levels showed a non-significant decline (p = 0.1).

Table 3: Weight Loss Post-Bariatric Surgery.

Variables	SG		Gastric Bypass		P-value
	Mean ± SD	**95% CI for Mean**	**Mean ± SD**	**95% CI for Mean**	
Weight Loss (%)	26.08 ± 15.24	(25.11 - 27.05)	26.38 ± 16.46	(24.55 - 28.21)	0.776
Excess weight loss (%)	62.71 ± 35.01	(60.51 – 64.91)	64.78 ± 34.63	(60.60 – 68.95)	0.392
Follow-up period (years)	2.27 ± 2.14	(2.14 - 2.40)	1.63 ± 1.66	(1.43 - 1.82)	<0.001**

*P-value was computed by univariate general linear model (adjusted for follow-up period); **Significant at 0.01 level; SG = Sleeve Gastrectomy; BMI = Body Mass Index; SD = Standard Deviation; CI = Confidence Interval.*

Weight loss outcomes were comparable between SG and gastric bypass. Mean weight loss was 26.08 ± 15.24% for SG and 26.38 ± 16.46% for gastric bypass (p = 0.776). Excess weight loss (EWL) was also similar between the groups (62.71 ± 35.01% vs. 64.78 ± 34.63%; p = 0.392). SG patients, however, had a significantly longer mean follow-up, which may influence comparative interpretation (2.27 ± 2.14 vs. 1.63 ± 1.66 years, $p < 0.001$). Boxplot analysis (Figure 1) showed typical weight loss ranges of 15–35% for both groups, though a minority of patients experienced weight regain, with outliers gaining up to 87.7% in the SG group and 67.5% in the gastric bypass group.

Table 4: Diabetes Remission rate in Sleeve Gastrectomy and Gastric Bypass according to Follow-up periods.

DM remission	Surgery	Follow-up period (years) <1 year	1-5 years	>5 years	Total
		n (%)	**n (%)**	**n (%)**	**n (%)**
Yes	SG[1]	9 (20)	28 (62.2)	8 (17.8)	45 (100)
	Gastric Bypass	6 (21.4)	22 (78.6)	0 (0)	28 (100)
No	SG	2 (14.3)	8 (57.1)	4 (28.6)	14 (100)
	Gastric Bypass	5 (31.3)	11 (68.8)	0 (0)	16 (100)

1 SG: Sleeve Gastrectomy

Among the 103 patients with type 2 diabetes, 70.9% (n = 73) achieved remission. SG demonstrated a higher remission rate (76.3%) compared to gastric bypass (63.6%), but this difference was not statistically significant (p = 0.163). Remission was most commonly achieved within 1–5 years post-surgery (SG: 62.2%, Gastric Bypass: 78.6%), with no gastric bypass patients achieving remission beyond five years.

Table 5: Binary Logistic Regression Analysis of predictors for Diabetes Remission.

Predictors	P-value	Odd Ratio	95% CI for Odd Ratio Lower	Upper
Pre-Age	0.010*	0.928	0.876	0.982
Pre-op BMI[1]	0.611	1.023	0.938	1.115
Weight Loss	0.246	1.029	0.981	1.079
Pre-op C-peptide (ng/ml)	0.038*	1.923	1.036	3.568
Pre-op Hemoglobin A1c (HbA1c) (%)	0.330	0.843	0.598	1.188

Pre-op Insulin[2]	0.005**	5.95	1.71	20.83

1. BMI: Body Mass Index
*2. The reference group is the patients on insulin therapy; *Significant at 0.05; **Significant at 0.01.*

Binary logistic regression identified younger age (OR = 0.928, p = 0.010), higher preoperative C-peptide levels (OR = 1.923, p = 0.038), and absence of insulin therapy (OR = 5.95, p = 0.005) as significant independent predictors of diabetes remission. Other variables, including preoperative BMI, HbA1c, and weight loss percentage, were not statistically associated with remission in this cohort.

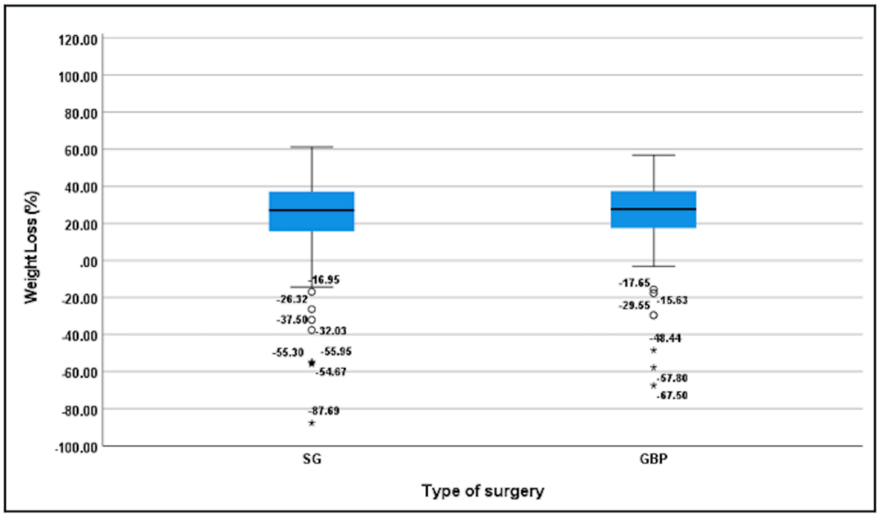
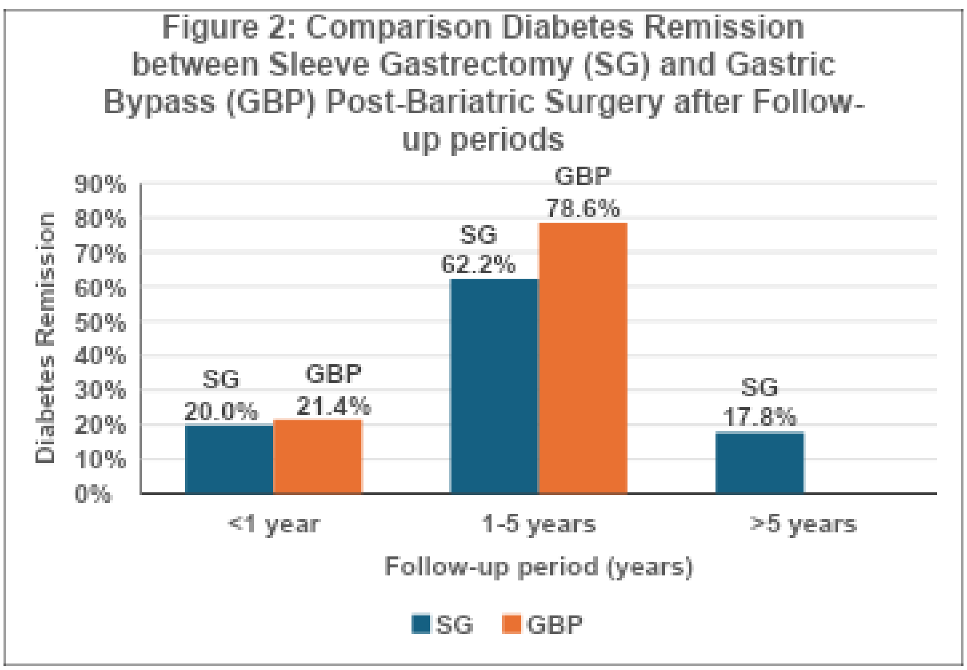


Figure 1: Simple box plot of weight loss according to the type of surgery.



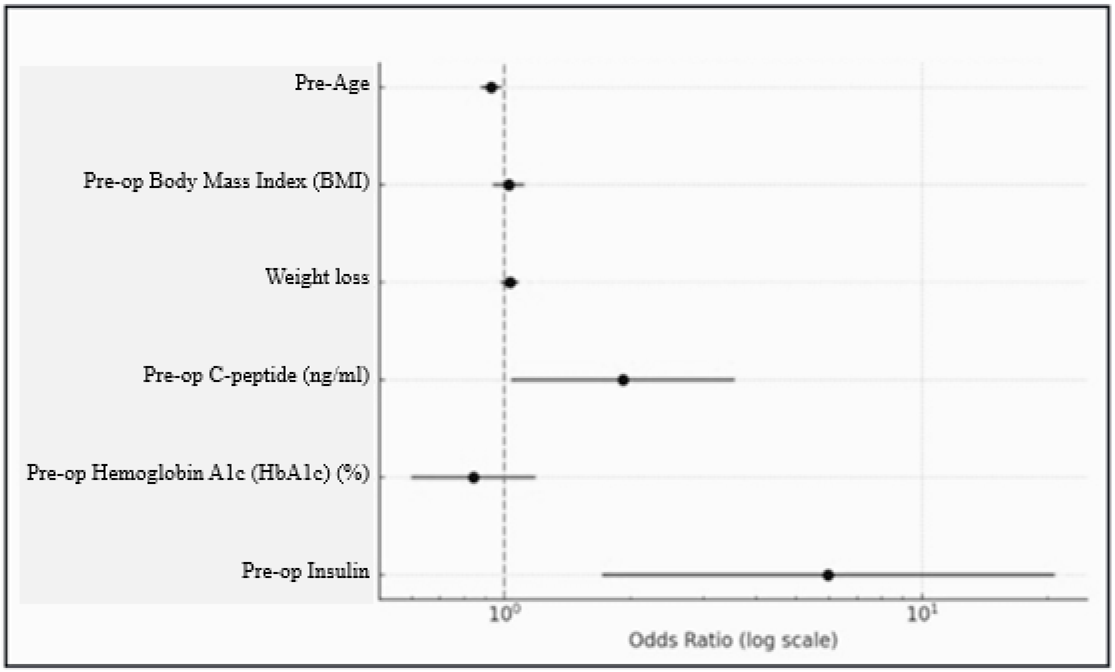


Figure 3 Forest plot of diabetes remission predictors

Discussion

This study provides a detailed assessment of metabolic and clinical outcomes following bariatric surgery in a large cohort of patients treated at a single center in Bahrain. By grouping restrictive procedures under sleeve gastrectomy (SG) and malabsorptive ones under gastric bypass, the analysis offers practical comparisons of the two major surgical approaches in terms of weight loss, metabolic improvement, and diabetes remission.

Consistent with findings from previous randomized trials such as SM-BOSS,[20] both SG and gastric bypass resulted in substantial weight loss, with no significant difference between them in terms of total or excess weight loss. Although both groups showed substantial weight loss, some outliers experienced regain—likely linked to lifestyle adherence, metabolic adaptation, or behavioral factors—highlighting the need for long-term multidisciplinary follow-up.

Diabetes remission was achieved in 70.9% of patients, as defined by ADA criteria as HbA1c <6.5% for at least three months without glucose-lowering medications, supporting the strong metabolic impact of bariatric surgery.While SG showed a numerically higher remission rate than gastric bypass (76.3% vs. 63.6%), this difference did not reach statistical significance after adjustment for age, C-peptide levels, and insulin use. However, SG's slightly better outcomes, combined with its lower complication profile and simpler operative course, may offer a clinical advantage in appropriate patients. From a practical perspective, these trends support the broader adoption of SG, especially in lower-risk or resource-limited settings.

The remission rates observed at <1 year, 1–5 years, and >5 years reflect different patient groups, rather than continuous follow-up of the same individuals. The absence of diabetes remission beyond five years in the gastric bypass group is noteworthy and likely influenced by multiple factors. Long-term remission depends not only on the type of surgery but also on weight maintenance, residual beta-cell function, and adherence to lifestyle modifications. These findings emphasize the need for individualized, long-term follow-up strategies to monitor for relapse and provide early intervention when needed.Among the strongest predictors of diabetes remission were younger age, higher preoperative C-peptide levels, and the absence of insulin therapy.[21] Systematic reviews and meta-analyses have also identified scoring models—such as the ABCD score and DiaRem—that incorporate these variables to predict remission with high accuracy.[22-24] These factors likely reflect preserved beta-cell reserve and earlier disease stage—characteristics that enhance the potential for metabolic reversal. Conversely, preoperative BMI, HbA1c, and even the degree of weight loss did not significantly predict remission, underscoring that diabetes reversal is not solely a function of weight reduction. This insight supports a shift toward more personalized surgical selection criteria that consider metabolic potential rather than weight alone.

Compared to prior studies at our center that reported higher rates of postoperative deficiencies, our study suggests that recent enhancements in nutritional protocols —perhaps through more consistent supplementation and structured follow-up—have had a positive impact.While revision surgeries were relatively uncommon, affecting 3.4% of the cohort, they offer insights into longer-term surgical trajectories. Some patients had undergone prior interventions before their index surgery, while others required revision later. Reasons for reoperation likely include inadequate weight loss, weight regain, or procedural complications such as GERD. Although small in number, these cases underscore the importance of preoperative planning, realistic expectations, and timely detection of suboptimal outcomes..

In summary, this study adds to the growing body of evidence supporting the metabolic efficacy of bariatric surgery—particularly SG—in diverse populations. It also emphasizes the complexity of outcomes, which are shaped not just by surgical choice, but by patient characteristics, perioperative care, and long-term follow-up. Going forward, optimizing patient selection and tailoring postoperative support may prove as important as the procedure itself in achieving durable clinical success.

The outcomes observed in this study align closely with global and regional evidence on the efficacy of bariatric surgery in improving metabolic parameters and achieving diabetes remission. International randomized controlled trials such as the Oseberg study in Norway reported diabetes remission rates of 74% following Roux-en-Y gastric bypass (RYGB) and 62% after sleeve gastrectomy (SG), with significant but non-persistent differences over the long term.[25,26] Our findings of a 70.9% overall remission rate are consistent with this international benchmark and slightly favor SG—a pattern echoed in recent meta-analyses.[27, 28] A UK-based population study showed a 67–73% remission range depending on the surgical method and diabetes duration.[29] Swedish registry data showed that longer diabetes duration inversely correlated with remission, supporting our observations regarding the predictive value of preoperative C-peptide and absence of insulin therapy.[30]

Regional data from the Middle East reinforce these findings, particularly for sleeve gastrectomy (SG). A Kuwait multicenter study showed a 69% diabetes remission rate post-SG, aligning with our results. Emirati cohorts also reported remission rates of 62–71%, confirming SG's effectiveness, though one study noted greater long-term weight regain.[31-33] This study has several strengths that support the reliability and relevance of its findings. With a large sample size and long-term follow-up, this is the first study of its scale in Bahrain, offering region-specific insights into bariatric outcomes. The inclusion of multiple surgical types, broad metabolic markers, and diverse patient profiles enhances its generalizability to everyday clinical practice.

However, several limitations must be acknowledged. As a retrospective study, our analysis cannot establish causality, and the lack of a non-surgical control group limits the ability to attribute observed changes exclusively to the surgical intervention. Variability in follow-up duration, patient adherence, and incomplete data may have affected the accuracy of long-term comparisons.

In addition, the study did not account for certain key predictors of diabetes remission—such as diabetes duration and the number or class of glucose-lowering medications—due to incomplete documentation in the electronic medical records. Furthermore, several unmeasured confounding factors, including physical activity levels, dietary adherence, psychosocial influences, socioeconomic status, thyroid function, and concurrent medication use, were not systematically captured. These variables are known to impact weight loss and glycemic control and may partially explain inter-individual variability in outcomes, particularly in cases of weight regain or remission relapse.Future prospective studies with standardized follow-up protocols and broader data collection are needed to confirm and build on these results.

The findings of this study carry several important clinical implications for bariatric surgical practice and the long-term management of obesity-related metabolic disease in Bahrain and similar populations.

First, both restrictive and malabsorptive procedures were effective in producing significant weight loss and metabolic improvement. However, sleeve gastrectomy (SG) may be particularly advantageous in routine clinical practice due to its technical simplicity, lower complication rates, and comparable efficacy to gastric bypass in achieving diabetes remission. In a healthcare context where minimizing surgical risk is a priority, SG represents a favorable choice, especially for patients with lower perioperative risk profiles.

Patient selection should incorporate the key predictors of diabetes remission identified in this cohort—namely younger age, higher preoperative C-peptide levels, and absence of insulin therapy. These factors likely reflect preserved beta-cell function and earlier disease stage, offering a more favorable physiological environment for metabolic reversal. Tailoring surgical decision-making around these variables may improve long-term outcomes and optimize resource allocation by prioritizing candidates with the highest likelihood of benefit.

Equally critical is the development of structured long-term metabolic follow-up programs aimed at sustaining improvements beyond the initial surgical period. The decline in remission observed after five years, particularly in the gastric bypass group, underscores the importance of regular, multidisciplinary follow-up. Dedicated bariatric clinics embedded within primary care or endocrine services could provide ongoing assessment of glycemic control, weight maintenance, nutritional status, and psychological health. Tailored interventions—including early identification of remission relapse, reinforcement of lifestyle behaviors, and individualized counseling—may enhance long-term outcomes. Integration of electronic health records, automated reminders, and telemedicine can further improve continuity of care, especially for patients with mobility or access limitations.

Finally, these clinical observations suggest important directions for future research. The predictors of remission identified here could form the basis for precision-medicine models that incorporate metabolic and molecular profiling. Prospective studies that integrate transcriptomic and proteomic data may lead to predictive algorithms capable of personalizing surgical interventions and maximizing therapeutic benefit. As the field advances toward individualized care, understanding the mechanistic pathways underlying remission will be essential to refining both surgical strategy and long-term metabolic care.

Conclusion

This study provides strong evidence supporting the effectiveness of both restrictive and malabsorptive bariatric procedures—specifically sleeve gastrectomy (SG) and one-anastomosis gastric bypass (OAGB)—in achieving substantial weight loss and meaningful metabolic improvement in a Bahraini population. Both surgical approaches demonstrated comparable efficacy in promoting weight loss and diabetes remission; however, SG may offer practical advantages in clinical settings due to its technical simplicity and lower complication profile.

A particularly important finding is the high rate of diabetes remission, which was most likely among younger patients, those with higher preoperative C-peptide levels, and those not requiring insulin therapy. These predictors should inform patient selection and individualized care strategies to enhance surgical success.

Moreover, the significant improvements observed in vitamin B12, vitamin D, and iron-related markers highlight the role of comprehensive nutritional support in maintaining long-term health benefits following surgery. These findings reinforce the value of bariatric surgery as a metabolic intervention and underscore the importance of sustained, multidisciplinary follow-up to support durable outcomes.

Based on the findings of this study, sleeve gastrectomy (SG) may be the preferred bariatric procedure for the Bahraini population, particularly for high-risk patients, given its simpler surgical technique and lower complication rates. Patient selection should prioritize individuals who are younger, have higher preoperative C-peptide levels, and are not on insulin therapy, as these factors were strongly associated with higher rates of diabetes remission.

To support long-term metabolic health after surgery, the establishment of a structured follow-up system is essential. This should include regular postoperative appointments, integration of dedicated bariatric clinics within primary care services, and the use of electronic health records (EHRs) to streamline monitoring and enhance continuity of care. Telemedicine and remote health platforms can further improve access, particularly for patients with mobility or geographic barriers.

Finally, the implementation of coordinated care pathways—linking primary care, surgical teams, and allied health professionals—along with feedback systems to monitor outcomes, can help ensure that patients receive comprehensive and responsive long-term care. These strategies are critical for sustaining the benefits of bariatric surgery and minimizing risks of relapse or nutritional complications.

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Disclosure

No Conflict of Interest. The study was approved by the Research Ethics Committee of the Royal Medical Services in Bahrain.

References

1. Bahrain National Survey 2018 [Internet]. Information & eGovernemnt Authority. 2018 [cited 18th of July 2024]. Available from: https://www.iga.gov.bh/Media/Agencies/Bahrain%20National%20Health%20Survey%202018%20English.pdf.

2. Yang M, Liu S, Zhang C. The Related Metabolic Diseases and Treatments of Obesity. Healthcare. 2022;10(9):1616.

3. Dobrowolski P, Prejbisz A, Kuryłowicz A, Baska A, Burchardt P, Chlebus K, et al. Metabolic syndrome - a new definition and management guidelines: A joint position paper by the Polish Society of Hypertension, Polish Society for the Treatment of Obesity, Polish Lipid Association, Polish Association for Study of Liver, Polish Society of Family Medicine, Polish Society of Lifestyle Medicine, Division of Prevention and Epidemiology Polish Cardiac Society, "Club 30" Polish Cardiac Society, and Division of Metabolic and Bariatric Surgery Society of Polish Surgeons. Archives of Medical Sceinces. 2022;18(1734-1922 (Print)).

4. Zimmet PZ, Magliano DJ, Herman WH, Shaw JE. Diabetes: a 21st century challenge. The lancet Diabetes & endocrinology. 2014;2(1):56-64.

5. Roth GA, Mensah GA, Johnson CO, Addolorato G, Ammirati E, Baddour LM, et al. Global Burden of Cardiovascular Diseases and Risk Factors, 1990–2019: Update From the GBD 2019 Study. Journal of the American College of Cardiology. 2020;76(25):2982-3021.

6. Younossi ZM, Golabi P, Paik JM, Henry A, Van Dongen C, Henry L. The global epidemiology of nonalcoholic fatty liver disease (NAFLD) and nonalcoholic steatohepatitis (NASH): a systematic review. Hepatology (Baltimore, Md). 2023;77(4):1335-.

7. Maurizio De Luca MZ, Giovanni Antonio Silverii, Benedetta Ragghianti, Giulia Bandini, Pietro Forestieri, Marco Antonio Zappa, Giuseppe Navarra, Diego Foschi, Mario Musella, Giuliano Sarro, Vincenzo Pilone, Enrico Facchiano, Mirto Foletto, Stefano Olmi, Marco Raffelli, Rosario Bellini, Paolo Gentileschi, Maria Rosaria Cerbone, Ilenia Grandone, Giovanna Berardi, Nicola Di Lorenzo, Marcello Lucchese, Luigi Piazza, Giovanni Casella, Emilio Manno, Alberto Zaccaroni, Alessandro Balani, Edoardo Mannucci & Matteo Monami. Bariatric Surgery for Patients with Overweight/Obesity. A Comprehensive Grading Methodology and Network Metanalysis of Randomized Controlled Trials on Weight Loss Outcomes and Adverse Events. Obesity Surgery. 2023;33(1):3-14.

8. Gloy VL, Briel M, Bhatt DL, Kashyap SR, Schauer PR, Mingrone G, et al. Bariatric surgery versus non-surgical treatment for obesity: a systematic review and meta-analysis of randomised controlled trials. BMJ. 2013;347.

9. Courcoulas AP, Daigle CR, Arterburn DE. Long term outcomes of metabolic/bariatric surgery in adults. BMJ. 2023;383:e071027.

10. Mirghani H, Altedlawi Albalawi I. Metabolic surgery versus usual care effects on diabetes remission: a systematic review and meta-analysis. Diabetology & Metabolic Syndrome. 2023;15.

11. Shamsi N, Patel V. The Cardiovascular Events in Metabolic Surgery Compared to the New Classes of Glucose-Lowering Agents in Patients with T2DM. J Endo Metabol Res. 2021;2(2):1-26.

12. Gulinac M, Miteva DG, Peshevska-Sekulovska M, Novakov IP, Antovic S, Peruhova M, et al. Long-term effectiveness, outcomes and complications of bariatric surgery. World journal of clinical cases. 2023;11(19):4504-12.

13. Saeed MF, Abualsel A, Sakrani NF. Initial One Year Pioneering Experience in Advanced Laparoscopic Bariatric Surgery. Bahrain Medical Bulletin. 2015;37(4):226-9.

14. Al Khalifa K, Al Ansari A. Quality of life, food tolerance, and eating disorder behavior after laparoscopic gastric banding and sleeve gastrectomy - results from a middle eastern center of excellence. BMC Obesity. 2018;5(1).

15. Hasan NA, Freije A, Abualsel A, Al-Saati H, Perna S. Effect of Bariatric Surgery on Weight Loss, Nutritional Deficiencies, Postoperative Complications and Adherence to Dietary and Lifestyle Recommendations: A retrospective cohort study from Bahrain. Sultan Qaboos University medical journal. 2020;20(3):344-51.

16. Mohamed AI, Bucheeri MM, Abulsel AY, Jose B. Laparoscopic sleeve gastrectomy with transit loop bi-partition: A novel bariatric procedure. International Journal of Surgery Open. 2020;22:33-7.

17. Alkhalifa S. Cost-benefit and cost-effectiveness of restrictive and hybrid bariatric surgery in Bahrain. 2022.

18. Alanzi A, Alamannaei F, Abduljawad S, Ghuloom A, Alahmed FA, Alzaidani AE, et al. Patient Outcomes and Rate of Intensive Care Unit Admissions Following Bariatric Surgery: A Retrospective Cohort Study of 775 Patients. Cureus. 2023;15(11).

19. Lean MEJ, Leslie WS, Barnes AC, Brosnahan N, Thom G, McCombie L, et al. Durability of a primary care-led weight-management intervention for remission of type 2 diabetes: 2-year results of the DiRECT open-label, cluster-randomised trial. Lancet Diabetes Endocrinol. 2019;7(5):344-55.

20. Peterli R, Wölnerhanssen BK, Peters T, Vetter D, Kröll D, Borbély Y, et al. Effect of Laparoscopic Sleeve Gastrectomy vs Laparoscopic Roux-en-Y Gastric Bypass on Weight Loss in Patients With Morbid Obesity: The SM-BOSS Randomized Clinical Trial. JAMA : the journal of the American Medical Association. 2018;319(3):255-65.

21. Lee WJ, Chong K, Ser KH, Chen JC, Lee YC, Chen SC, et al. C-peptide predicts the remission of type 2 diabetes after bariatric surgery. Obes Surg. 2012;22(2):293-8.

22. Singh P, Adderley NJ, Hazlehurst J, Price M, Tahrani AA, Nirantharakumar K, et al. Prognostic Models for Predicting Remission of Diabetes Following Bariatric Surgery: A Systematic Review and Meta-analysis. Diabetes care. 2021;44(11):2626-41.

23. Sohal DS, Nain PS, Singh P, Ahuja A, Singh A. ABCD score of > 6 predicts diabetes remission following bariatric surgery. International journal of diabetes in developing countries. 2020;40(3):416-21.

24. de Abreu Sesconetto L, da Silva RBR, Galletti RP, Agareno GA, Colonno BB, de Sousa JHB, et al. Scores for Predicting Diabetes Remission in Bariatric Surgery: a Systematic Review and Meta-analysis. Obesity Surgery. 2023;33:600-10.

25. Hofso D, Fatima F, Borgeraas H, Birkeland KI, Gulseth HL, Hertel JK, et al. Gastric bypass versus sleeve gastrectomy in patients with type 2 diabetes (Oseberg): a single-centre, triple-blind, randomised controlled trial. Lancet Diabetes Endocrinol. 2019;7(12):912-24.

26. Wagen Hauge J, Borgeraas H, Birkeland KI, Johnson LK, Hertel JK, Hagen M, et al. Effect of gastric bypass versus sleeve gastrectomy on the remission of type 2 diabetes, weight loss, and cardiovascular risk factors at 5 years (Oseberg): secondary outcomes of a single-centre, triple-blind, randomised controlled trial. Lancet Diabetes Endocrinol. 2025;13(5):397-409.

27. Borgeraas H, Hofso D, Hertel JK, Hjelmesaeth J. Comparison of the effect of Roux-en-Y gastric bypass and sleeve gastrectomy on remission of type 2 diabetes: A systematic review and meta-analysis of randomized controlled trials. Obes Rev. 2020;21(6):e13011.

28. Kermansaravi M, Chiappetta S, Kassir R, Bosco A, Giudicelli X, Lainas P, et al. Efficacy of One Anastomosis Gastric Bypass Versus Sleeve Gastrectomy and Roux-en-Y Gastric Bypass for the Treatment of Type 2 Diabetes Mellitus: a Systematic Review and Meta-Analysis of Randomized Clinical Trials. Obesity Surgery. 2024;34(12):4555-62.

29. Yska JP, van Roon EN, de Boer A, Leufkens HGM, Wilffert B, de Heide LJM, et al. Remission of Type 2 Diabetes Mellitus in Patients After Different Types of Bariatric Surgery: A Population-Based Cohort Study in the United Kingdom. JAMA Surgery. 2015;150(12):1126-33.

30. Jans A, Naslund I, Ottosson J, Szabo E, Naslund E, Stenberg E. Duration of type 2 diabetes and remission rates after bariatric surgery in Sweden 2007-2015: A registry-based cohort study. PLoS Med. 2019;16(11):e1002985.

31. Al Sabah S, Al Haddad E. The Utilization of Bariatric Surgery in Patients With and Without Diabetes: Results from the Second Kuwait National Bariatric Surgery Database Report. Bariatric surgical practice and patient care. 2024;19(1):2-27.

32. Allum M, Buckley A, Suliman SGI, Suliman M, Hamdan K, Al Hadad M. Outcomes Following Metabolic Bariatric Surgery at a Single Center in the United Arab Emirates. Diabetes Metab Syndr Obes. 2025;18:249-60.

33. Bhatti R, Bereczky B, Joumaa M, Warshow U, Aljabiri M, Khamis AH, et al. Efficacy of bariatric surgery in improving the anthropomertics and metabolic outcomes: a retrospective study from a single private center in Dubai, UAE. J Surg. 2022;7(11):1-5.