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ORIGINAL RESEARCH

Bariatric surgery outcomes: a single-center study in the United Arab Emirates

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Background: Bariatric surgery has become an attractive treatment for severe obesity over the last decade, due to its impacts on weight loss and remission of type 2 diabetes and metabolic syndrome. In the United Arab Emirates, a country where the rate of obesity is dramatically increasing bariatric surgery has gained popularity in recent years; however, published data on its outcomes in the Emirati population are lacking.

Methods: We retrospectively reviewed the medical records of 95 patients who underwent bariatric surgery (ie, laparoscopic Roux-en-Y gastric bypass [RYGB] or laparoscopic sleeve gastrectomy) at the Rashid Center for Diabetes and Research in Ajman, United Arab Emirates. Weight outcomes and metabolic marker data were abstracted at baseline and at 3, 6, and 12 months postoperatively.

Results: Laparoscopic RYGB was the main procedure performed by our bariatric unit. All variables demonstrated postoperative improvement. An average excess weight loss of 68% was observed at 12 months. Fat mass was the body component that decreased the most, with an average reduction of 46%. Additionally, lipid profiles were significantly different ($P<0.01$) at 12 months, with triglyceride levels improving by 27% and low-density lipoprotein levels improving by 21%. Similarly, glycated hemoglobin (HbA_{1c}) levels decreased significantly ($P<0.001$) in patients with type 2 diabetes, with an average reduction of 73%.

Conclusion: Our results show that a substantial short-term reduction in weight and significant improvements in metabolic markers followed bariatric surgery in severely obese Emirati patients. Our results are consistent with the outcomes of other internationally published studies. Additional studies are warranted to determine whether the favorable impacts of bariatric surgery can be sustained over the long term.

Keywords: laparoscopic RYGB, laparoscopic sleeve gastrectomy, lipid profile, type 2 diabetes

Introduction

Obesity and its comorbidities, including diabetes and cardiovascular disease, are considered to have serious impacts that increase the public health burden worldwide.¹ The same is true in the United Arab Emirates (UAE), a country that has encountered a dramatic transformation in its economy and society since the first exports of oil in 1962. The UAE has one of the highest proportions of overweight and obese adults aged 15 years and older in the Eastern Mediterranean region.² Two non-communicable diseases that are attributable to obesity, ie, diabetes and cardiovascular disease, have been identified by the local Ministry of Health as the leading cause of mortality in the UAE.³ Beyond its impact on mortality, obesity has been suggested to be the main driver of increasing health care costs in many countries.⁴ As body mass index (BMI)

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increases, the associated direct health care costs and losses of productivity increase correspondingly.⁴ In the UAE, the costs associated with caring for diabetes, one of the metabolic consequences of obesity, are high (\$1,605 per diabetic patient) and those associated with the management of its complications are significantly higher (\$5,645 per diabetic patient).⁵

Many treatment options exist for the management of obesity, including both nonsurgical and surgical treatments. Dietary therapy, physical activity, behavior therapy, pharmacotherapy, or combinations of these strategies are considered effective nonsurgical weight loss interventions.⁶ However, in patients with severe obesity ($BMI \geq 40 \text{ kg/m}^2$) or with $BMI \geq 35 \text{ kg/m}^2$ and associated comorbidities, and for whom these strategies have failed to produce the desired weight loss, a surgical approach is suggested.⁶ Moreover, bariatric surgery has been shown to be superior to nonsurgical approaches in terms of weight loss and remission of type 2 diabetes and metabolic syndrome over both the short term and long term.^{7,8} Indeed, bariatric surgery is considered an appealing treatment for severe obesity worldwide. In the last decade, the number of bariatric surgeries performed worldwide has increased substantially, doubling between 2003 and 2008 from 143,301 to 344,221 procedures per year.⁹ Similarly, in the UAE, bariatric surgery has become a favored treatment for severe obesity in recent years; 1,963 such surgeries were performed in 2011 alone.¹⁰ The two most commonly performed bariatric procedures in the UAE and internationally are the laparoscopic Roux-en-Y gastric bypass (RYGB) and laparoscopic sleeve gastrectomy.¹⁰

A recent report comparing bariatric outcome in the UAE with that in American College of Surgeons National Surgical Quality Improvement Program hospitals found that outcomes were similar for most postoperative variables.¹¹ The report focused on the safety of bariatric surgery in terms of postoperative complications; changes in weight and metabolic markers were not reported. Despite this similarity in the quality of health care for bariatric patients, it would be inaccurate to presume that the same similarities would exist in terms of metabolic outcomes, because other factors such as ethnicity might affect the outcome of bariatric surgery.¹² Despite the marked increase in bariatric surgery in the Arab Gulf region over the last decade, no data have been published on its metabolic outcomes in adults with this ethnic background. To the best of our knowledge, this is the first study to report bariatric metabolic outcomes in an Emirati population. This retrospective study reports results obtained by the bariatric program at the Rashid Center for Diabetes and Research (RCDR) in Ajman, UAE, and describes the preoperative

and postoperative care programs, patient characteristics, and short-term postoperative outcomes (weight and comorbidity parameters). The results obtained here were compared with those obtained internationally.

Materials and methods

Bariatric unit at RCDR

The bariatric surgery unit at RCDR adopted three main objectives when it was first established: first, to develop the bariatric surgery pathway based on recently developed guidelines; second, to set up a multidisciplinary team (including an endocrinologist, bariatric surgeon, nurse, dietitian, anesthesiologist, cardiologist, and psychiatrist) to provide comprehensive care for patients before and after surgery; and third, to set up a long-term follow-up plan for all patients who have undergone bariatric surgery at RCDR.

Subjects

All patients offered surgical intervention were at least 18 years old and had been referred to the bariatric unit at RCDR. Patients included in this study were those with complete data on demographics, weight, and clinical outcomes, and eligible for the 1-year follow-up. All patients provided written informed consent prior to the surgical procedure after a thorough discussion with the multidisciplinary team during the preoperative care program. Either laparoscopic RYGB or laparoscopic sleeve gastrectomy was offered, depending on the individualized therapy goals, patient preferences, and risk assessments. Most patients underwent laparoscopic RYGB; 12-month follow-ups were completed in February 2014. The study was approved by the ethical review committee at the RCDR, Ajman.

Preoperative care

As a prerequisite for enrolling in the preoperative program, all potential candidates attended a group seminar describing the benefits and risks of bariatric surgery. The entire multidisciplinary bariatric team was involved in the educational session. Investigative individual consultations with the multidisciplinary team then followed, in which all potential candidates were screened for inclusion/exclusion criteria according to the American Society for Metabolic and Bariatric Surgery (ASMBS) guidelines.¹³ The ASMBS inclusion criteria for bariatric surgery candidates are as follows: $BMI \geq 40 \text{ kg/m}^2$ with no comorbidities or $BMI \geq 35 \text{ kg/m}^2$ with obesity-associated comorbidities, including type 2 diabetes, hypertension, hyperlipidemia, obstructive sleep apnea, and nonalcoholic fatty liver disease; failure in previous

nonsurgical attempts to lose weight; and the expectation that the patient will comply with postoperative care (follow-up visits with the health care team, and compliance with dietary supplements postoperatively and any instructions regarding the surgical procedure). Patients were excluded from the bariatric program based on ASMBS exclusion criteria, which are as follows: current drug or alcohol abuse; reversible endocrine or other disorder that can cause obesity; uncontrolled/severe psychiatric illness; and lack of comprehension of the risks/benefits/expected outcomes/lifestyle changes associated with bariatric surgery. If eligible for surgical intervention, patients were referred to the preoperative program. This included two to three scheduled visits with the endocrinologist, bariatric nurse, dietitian, cardiologist, anesthesiologist, and psychologist; during these visits, detailed assessments of medical history and continuous anthropometric, biochemical, and dietary assessments were conducted. One week before the surgery, an educational session was conducted to inform the patients regarding the admission process, the day of surgery, and post-surgery instructions (Figure 1).

Postoperative care

Surgeries were performed by one specialized bariatric surgeon at the adjacent Sheikh Khalifa Hospital, Abu Dhabi, under supervision by the bariatric surgery unit at RCDR. Patients' length of stay in the hospital depended on the type of surgery; the patients were discharged by the surgeon, based on their ability to drink 1.5 L of fluid over 24 hours without pain, nausea, vomiting, or other discomfort. Patients were then scheduled for a telephone call with the bariatric nurse 5 days after surgery and a clinic visit 10 days after surgery for suture/staple removal by the surgeon. This was followed by visits at 1, 3, 6, and 12 months, which included determination of outcome, reassessment by the endocrinologist, bariatric nurse, and dietitian, reinforcement of nutrition guidelines, and advice regarding vitamin/mineral supplement intake, if indicated.

Outcome measures

The following information was abstracted from patient medical records: sociodemographics, including age and sex; anthropometric data, including weight and height,

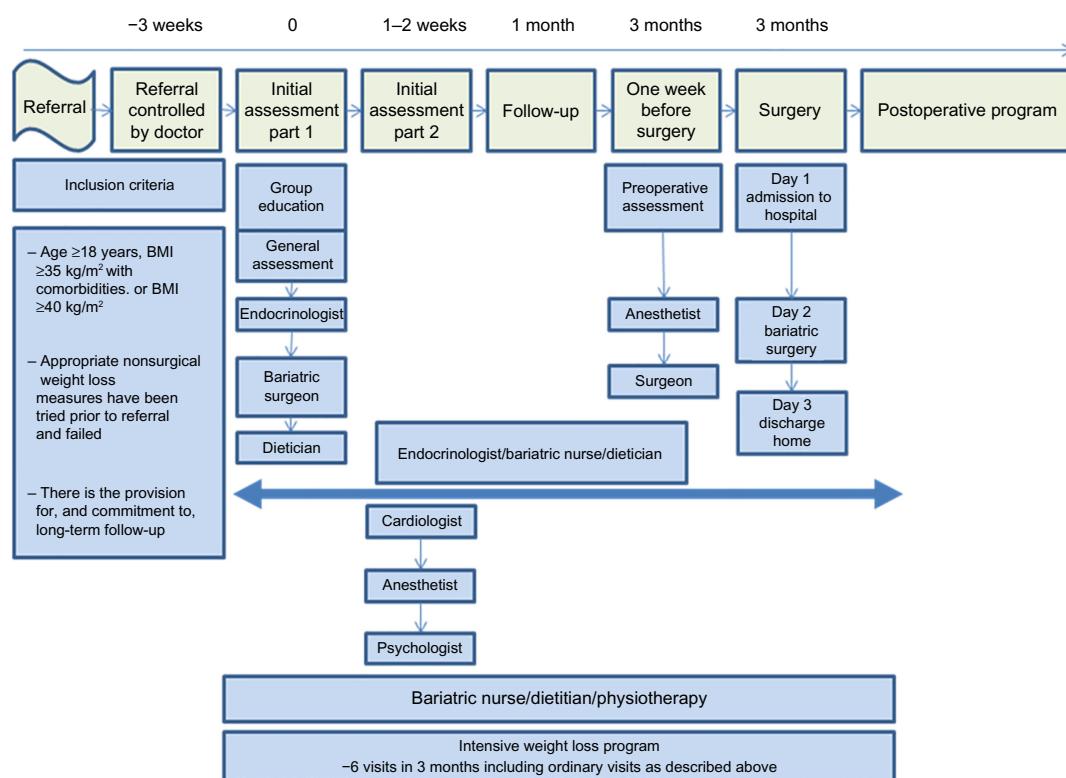


Figure 1 Preoperative bariatric program at Rashid Center for Diabetes and Research.

Notes: All candidates attended a group education seminar prior to the program, in which the entire multidisciplinary bariatric team was involved. Investigative individual consultations with the multidisciplinary team then followed, in which all potential candidates were screened for inclusion/exclusion criteria according to the American Society for Metabolic and Bariatric Surgery guidelines. If eligible for surgical intervention, patients were referred to the preoperative program. This program included two to three scheduled visits with the endocrinologist, bariatric nurse, dietitian, cardiologist, anesthesiologist, and psychologist, during which detailed assessments of medical history and continuous anthropometric, biochemical, and dietary assessments were conducted. One week before surgery, an educational session was conducted to inform the patients regarding the admission process, the day of surgery and post-surgery instructions.

Abbreviation: BMI, body mass index.

as measured by the bariatric nurse for all patients, BMI (calculated as weight [kg]/height [m^2]), body composition analysis, based on fat mass (kg), muscle mass (kg), water mass (kg), as measured by bioelectrical impedance using an InBody 230 equipment (Biospace, Korea) in accordance with standard operating procedures; metabolic marker outcomes, including blood pressure, as measured using a standard sphygmomanometer equipped with an appropriate cuff size, fasting blood glucose, insulin, and glycated hemoglobin (HbA_{1c}) levels, lipid profile (low-density lipoprotein, high-density lipoprotein, triglycerides, and total cholesterol), liver profile (alkaline phosphatase, alanine transaminase, aspartate transaminase, and gamma-glutamyl transferase), and albumin (all laboratory tests were conducted using a Roche Diagnostics machine, Japan); and any medication used by patients with type 2 diabetes, including biguanides (metformin), sulfonylureas (gliclazide), glucagon-like peptide-1 (GLP-1) agonist therapy (exenatide), antihypertensive medication (angiotensin receptor blockers), and medications for hyperlipidemia (statins).

Definitions

Percentage of excess weight loss (% EWL) was calculated by dividing the amount of weight loss after surgery by the amount of presurgery excess body weight (calculated as that excess to yield a BMI of $25\text{ kg}/m^2$) and multiplied by 100.¹⁴ Type 2 diabetes was defined using the American Diabetes Association definition of type 2 diabetes ($HbA_{1c} \geq 6.5\%$ or fasting blood glucose $\geq 7\text{ mmol/L}$). Complete remission of type 2 diabetes was defined using the American Diabetes Association definition: “ HbA_{1c} in the normal range and fasting blood glucose $<100\text{ mg/dL}$ for at least 1 year duration in the absence of active pharmacological agent or ongoing procedure”.¹⁵ Fat free mass (kg) was calculated by subtracting fat mass (kg) from total weight (kg).

All data were abstracted at baseline and at 3, 6, and 12 months postoperatively. Baseline assessment was that measured on the admission day, 1 day prior to surgery. This study focuses on the results of laparoscopic RYGB, because this is the main procedure performed by our bariatric unit; the results of laparoscopic sleeve gastrectomy are described only briefly (Figure 2).

Statistical analysis

All continuous data are presented as the mean \pm standard deviation, and categorical data are presented as frequencies. Student’s *t*-tests (paired and unpaired) were used to test the significance of differences between values for continuous

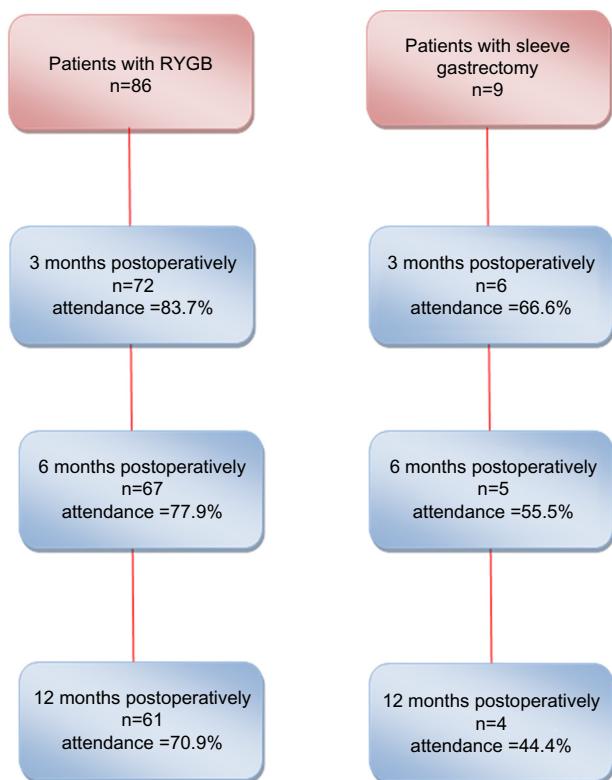


Figure 2 Patient follow-up flowchart for laparoscopic RYGB and laparoscopic sleeve gastrectomy, showing the numbers of patients who underwent each procedure at Rashid Center for Diabetes and Research and those with completed profiles at 3, 6, and 12 months.

Notes: As demonstrated, laparoscopic RYGB was the main procedure performed by our bariatric unit. Patients who achieved more than 50% EBW at 12 months had significantly lower body mass index at baseline ($P<0.001$).

Abbreviations: EBW, excessive body weight; RYGB, Roux-en-Y gastric bypass.

variables measured at baseline and at various time points. Differences with P -values <0.05 were considered to be statistically significant.

Results

Laparoscopic RYGB

Most patients (90%, $n=86$) underwent laparoscopic RYGB; of these, 72% were women ($n=62$). Table 1 shows the baseline characteristics of the patients. Men had significantly

Table I Baseline characteristics of the studied RYGB patients

Variable	RYGB ^a
n	86
Age, years	32.96 ± 8.28
Sex, n (%)	
Women	62 (72.09)
Men	24 (27.91)
Diabetes: no	26 (30.23)

Notes: ^aContinuous data are presented as the mean \pm standard deviation, and categorical data are presented as the number and frequency.

Abbreviation: RYGB, Roux-en-Y gastric bypass.

higher weight at baseline than women (137.68 ± 15.88 and 117.51 ± 15.64 kg, respectively, $P < 0.001$). Sixty-one of these patients (71%) had complete profiles at 12 months and 25 had incomplete profiles. At baseline, the weight of patients with complete profiles was significantly higher than that of those with incomplete profiles (126.32 ± 17.25 and 110.39 ± 16.38 kg, respectively, $P < 0.001$), and the same was true of BMI (47.04 ± 6.04 kg/m 2 and 41.83 ± 5.11 kg/m 2 , respectively, $P < 0.01$). Thirty percent (n=26) of patients had type 2 diabetes; among these, 73% (n=19) were women. No major complications (leakage, bleeding) were observed after surgery, with the exception of one patient who required reoperation to change sleeve gastrectomy to RYGB due to a corkscrew phenomenon secondary to anatomical predisposition (hanging stomach). The average length of stay in the hospital was 2–3 days. No deaths occurred postoperatively.

Weight

Patients had lost an average of 29.5% of their presurgery weight at 12 months after surgery (Table 2). Nine patients (15%) achieved a BMI of less than 25 kg/m 2 by 12 months postoperatively. Baseline and 12-month postoperative weights (126.32 ± 17.39 kg and 87.21 ± 15.24 kg, respectively, $P < 0.001$) and BMI (47.04 ± 6.03 kg/m 2 and 32.39 ± 6.01 kg/m 2 , respectively, $P < 0.001$) differed significantly in patients with a complete profile at 12 months (n=61). Men (n=19) achieved significantly greater weight loss at 12 months compared with women (n=42; 46.44 ± 14.76 and 35.49 ± 9.53 , respectively, $P < 0.01$). No significant difference in weight loss was found between diabetic (n=14) and nondiabetic (n=47) patients at 12 months ($P = 0.06$).

Percentage of excess weight loss

By 12 months postoperatively, 77% (n=47) of patients had achieved more than 50% EWL, compared with 51% (n=34) at 6 months (Figure 3). Diabetic (n=14) and nondiabetic (n=47) patients did not significantly differ in% EWL ($P < 0.18$) at 12 months. Baseline BMI significantly differed

($P < 0.001$) between patients who achieved EWL >50% at 12 months (n=48, 45.82 ± 5.25) and those who did not (n=13, 51.24 ± 6.3 ; Figure 1).

Body composition

The body component that decreased the most following surgery was fat mass. At 12 months, fat mass was reduced by 46%, muscle mass was reduced by 11.64%, and water mass was reduced by 12.68% (Figure 4). By 6 months, fat loss represented 75.48% of weight loss, and this remained the same even at 12 months (78.95%). The contributions of fat-free mass to weight loss were 24.52% and 21.05% at 6 and 12 months, respectively. Fat mass differed significantly between baseline (58.1 ± 10.74 kg) and 12 months (31.95 ± 13.71 kg) for patients with complete profiles (n=61, $P < 0.001$). At 12 months, men (n=19) had achieved significantly higher fat mass loss than women (n=42; 35.59 ± 11.75 kg and 24.3 ± 10.12 kg, respectively, $P < 0.01$). However, women lost significantly greater water mass than men (6.51 ± 3.93 kg and 3.96 ± 4.05 kg, respectively, $P = 0.04$).

Metabolic marker outcomes

Systolic and diastolic blood pressure decreased by 3.8% and 2.7%, respectively (Table 3). However, the decrease in diastolic blood pressure was not significant compared with baseline for patients with complete 12-month profiles ($P = 0.21$). All lipid profile measures (low-density lipoprotein, triglycerides, and total cholesterol) were significantly reduced ($P < 0.01$) at 12 months compared with baseline; triglyceride levels showed the greatest mean improvement (26.71%), followed by low-density lipoprotein (20.9%) and total cholesterol (12.26%). High-density lipoprotein increased significantly (25%) at 12 months ($P < 0.001$). The liver profile measures of gamma-glutamyl transferase, alanine transaminase, and aspartate transaminase decreased by 50.54%, 39.83%, and 15.41%, respectively, and these decreases were significant at 12 months ($P < 0.05$). Alkaline phosphatase slightly decreased (4.6%) but was not significantly different

Table 2 Weight outcomes for RYGB

Variable	RYGB ^a			
	Baseline (n=86)	3 months (n=72)	6 months (n=67)	12 months (n=61)
Weight (kg)	123.67 ± 18.03	99.96 ± 13.83^b	96.31 ± 15.54^b	87.43 ± 15.18^b
Weight loss (kg)	–	26.74 ± 13.86	32.59 ± 19.68	47.04 ± 25.5
BMI (kg/m 2)	45.99 ± 6.21^b	41.45 ± 5.71^b	36.53 ± 5.54^b	32.42 ± 5.93^b
BMI decrease (kg/m 2)	–	7.69 ± 5.18	12.22 ± 8.07	17.85 ± 9.9

Notes: ^aData are presented as the mean \pm standard deviation; ^bsignificantly different from baseline according to a paired t-test ($P < 0.000$).

Abbreviations: BMI, body mass index; RYGB, Roux-en-Y gastric bypass.

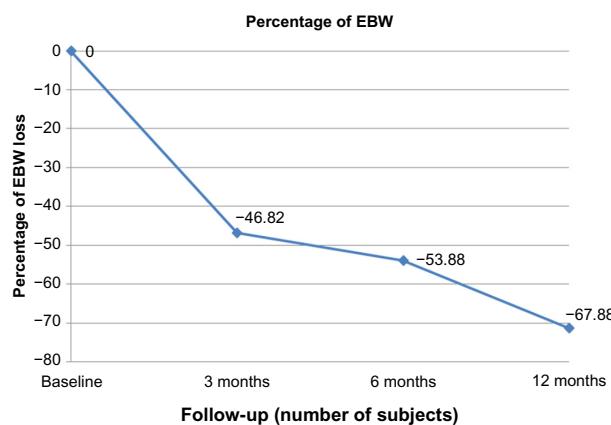


Figure 3 Excess body weight loss at various times after the laparoscopic RYGB procedure.

Notes: At 12 months, the average % EBW loss was approximately 68% for 61 patients with completed profiles. Approximately 77% of patients (n=47) lost more than 50% of EBW at 12 months compared with 51% (n=34) at 6 months. Baseline body mass index ($P<0.001$) significantly differed between patients who achieved an EBW loss >50% at 12 months (n=48, $45.82\pm5.25 \text{ kg/m}^2$) and those who did not (n=13, $51.24\pm6.3 \text{ kg/m}^2$).

Abbreviations: EBW, excessive body weight; RYGB, Roux-en-Y gastric bypass.

from baseline ($P=0.08$). Albumin also slightly decreased (2.47%) but not significantly ($P=0.25$). No significant difference was found between diabetics (n=14) and nondiabetics (n=47) for any variable except fasting blood glucose and HbA_{1c} ($P=0.02$ and $P=0.004$, respectively).

At the 12-month visit, fasting blood glucose, HbA_{1c}, and insulin levels had dramatically decreased by 66.35%, 73.37%, and 67.47%, respectively, for type 2 diabetic patients. This reduction was statistically significant ($P<0.001$) between baseline and 12 months for patients with complete profiles (n=15; Figure 5). At 6 months postoperatively, diabetic patients had dramatically reduced their use of antidiabetic medications (Figure 6). The use of biguanides (metformin) and sulfonylureas (gliclazide) was reduced by 89.2% and 88.88%, respectively. GLP-1 agonist (exenatide) and insulin use were completely stopped. Additionally, both the use of antihypertensive (angiotensin receptor blocker) and cholesterol-reducing (statin) medications decreased by 90%. By 6 months, 37% of patients (n=7) had achieved complete remission of type 2 diabetes, and by 12 months, 43% of patients (n=6) were cured of type 2 diabetes.

Sleeve gastrectomy

Eight patients underwent laparoscopic sleeve gastrectomy, of whom six were women (75%) and two were diabetics (25%). Four subjects had complete profiles at 12 months. Patients who underwent laparoscopic sleeve gastrectomy lost approximately 22.7% of their total weight and an average of 61.33%

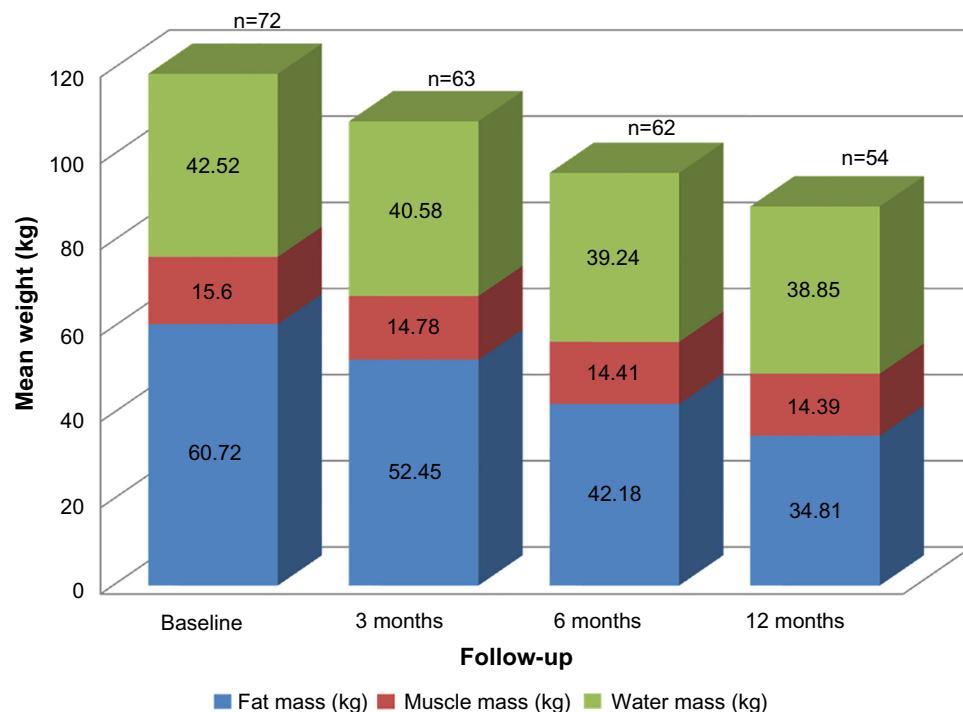


Figure 4 Changes in body composition at various times after laparoscopic RYGB surgery.

Notes: Fat mass decreased the most postoperatively. At 12 months, patients had achieved average reductions of 46% in fat mass, 11.64% in muscle mass, and 12.68% in water mass. Fat mass differed significantly between baseline ($58.1\pm10.74 \text{ kg}$) and 12 months ($31.95\pm13.71 \text{ kg}$) for patients with complete profiles (n=54, $P<0.001$). At 12 months, the 19 men achieved significantly greater fat mass loss than the 35 women ($35.59\pm11.75 \text{ kg}$ versus $24.3\pm10.12 \text{ kg}$, $P<0.01$).

Abbreviation: RYGB, Roux-en-Y gastric bypass.

Table 3 Changes in metabolic markers outcomes post RYGB

Variable	RYGB ^a			
	Baseline (n=86)	3 months (n=72)	6 months (n=67)	12 months (n=61)
HbA _{1c} (%) ^b	5.43±0.4	5.54±0.74	5.35±0.92	5.33±0.43
Fasting blood glucose (mmol/L) ^b	8.85±3.36	5.34±1.27	5.04±0.42	4.96 (0.5)
Insulin (μU/mL)	25.61±15.64	15.39±9.15 ^c	10.86±8.00 ^c	8.33±2.78 ^c
Blood pressure (mmHg)				
Systolic	128.36±14.16	123.33±11.59 ^c	120.07±11.62 ^c	123.45±13.10 ^c
Diastolic	72.34±10.96	70.56±9.12	69.69±9.29	69.66±9.21
Lipid profile				
LDL (mmol/L)	3.01±0.67	22.99±9.93 ^c	2.52±0.62 ^c	2.38±0.68 ^c
HDL (mmol/L)	1.20±1.2	3.73±2.25 ^c	1.34±0.38 ^c	1.5±0.38 ^c
Triglycerides (mmol/L)	1.31±0.61	1.33±0.39 ^c	0.95±0.33 ^c	0.96±0.75 ^c
Total cholesterol (mmol/L)	4.73±0.88	9.26±4.70 ^c	4.26±0.73 ^c	4.15±0.86 ^c
Liver profile				
ALP (IU/L)	74.84±20.65	64.92±19.92 ^c	71.01±21.03	71.4±23.32
ALT (IU/L)	27.44±20.93	32.36±23.15 ^c	18.75±11.2 ^c	16.51±7.6 ^c
AST (U/L)	20.51±8.43	23.14±10.04 ^c	17.35±6.97 ^c	17.11±5.99 ^c
GGT (IU/L)	29.84±16.52	11.96±7.21 ^c	15.66±7.4 ^c	14.76±6.45 ^c
Albumin (g/L)	40.89±2.87	40.37±3.7	40.69±2.67	41.9±8.28

Notes: ^aData are presented as the mean ± standard deviation; ^bvalues are presented for nondiabetic patients; ^csignificantly different from baseline according to a paired t-test ($P<0.05$).

Abbreviations: ALP, alkaline phosphatase; ALT, alanine transaminase; AST, aspartate transaminase; GGT, gamma-glutamyl transferase; HDL, high-density lipoprotein; LDL, low-density lipoprotein; RYGB, Roux-en-Y gastric bypass; HbA_{1c}, glycated hemoglobin.

(n=4) of excess body weight at 12 months. At 12 months after surgery, fat, muscle, and water mass decreased by 49.36%, 9.85%, and 9.84%, respectively. All laboratory test values were altered after sleeve gastrectomy. Triglycerides, low-density lipoprotein, and total cholesterol were reduced by 42.75%, 11.25%, and 8.2%, respectively, and high-density lipoprotein increased by 17.52%. Regarding liver enzymes, alanine transaminase, aspartate transaminase, and alkaline phosphatase were reduced by 50%, 24.61%, and 14.29%, respectively; gamma-glutamyl transferase was increased by 10.07%. No change was observed in albumin levels after surgery (0.37%).

Discussion

This retrospective study reported the short-term outcomes (weight and metabolic parameters) of bariatric surgery (focusing on laparoscopic RYGB) in Emirati adults. Although laparoscopic RYGB is one of the most commonly performed bariatric procedures used to treat severe obesity in the UAE, few data have been published regarding its outcome in Emiratis. Our study demonstrated the short-term positive impact of laparoscopic RYGB surgery on weight, body composition, and comorbidities, including lipid profiles. Likewise, glucose control was dramatically improved in patients with type 2 diabetes, and the use of antidiabetic medications decreased accordingly. Additionally, no evidence of major postoperative complications was found.

These positive outcomes of RYGB surgery are attributable to a complex interaction between several mechanisms. RYGB causes weight loss mainly through gastric restriction and surgical malabsorption.¹⁶ It has also been suggested that the surgery affects eating behavior. Patients normally experience appetite changes and reduced hunger after surgery, possibly due to changes in appetite and in the levels of satiety hormones including ghrelin, glucose-dependent insulinotropic peptide, GLP-1, and peptide YY.¹⁷ Moreover, patients might be cautious in their food selection and in the quantities consumed to avoid unpleasant symptoms associated with dumping syndrome (vomiting, nausea, abdominal discomfort) or when exceeding the capacity of their small gastric pouch.¹⁶ However, the dramatic improvement seen in glycemic control in type 2 diabetic patients after surgery is said to be independent of the treatment of obesity and is not entirely explained by postoperative weight loss and restriction of calorie intake.¹⁸ Alterations in the anatomy of the gastrointestinal tract and neural and hormonal changes (including changes in incretins) can partly explain the improvement in glycemic control after surgery; bariatric procedures such as laparoscopic RYGB can be considered an effective treatment strategy for type 2 diabetes.^{18,19} This concept was not assessed while developing the outcome measures in our bariatric program.

Despite the increased use of bariatric surgery in the UAE, published data on its outcomes in this population are lacking.¹⁰

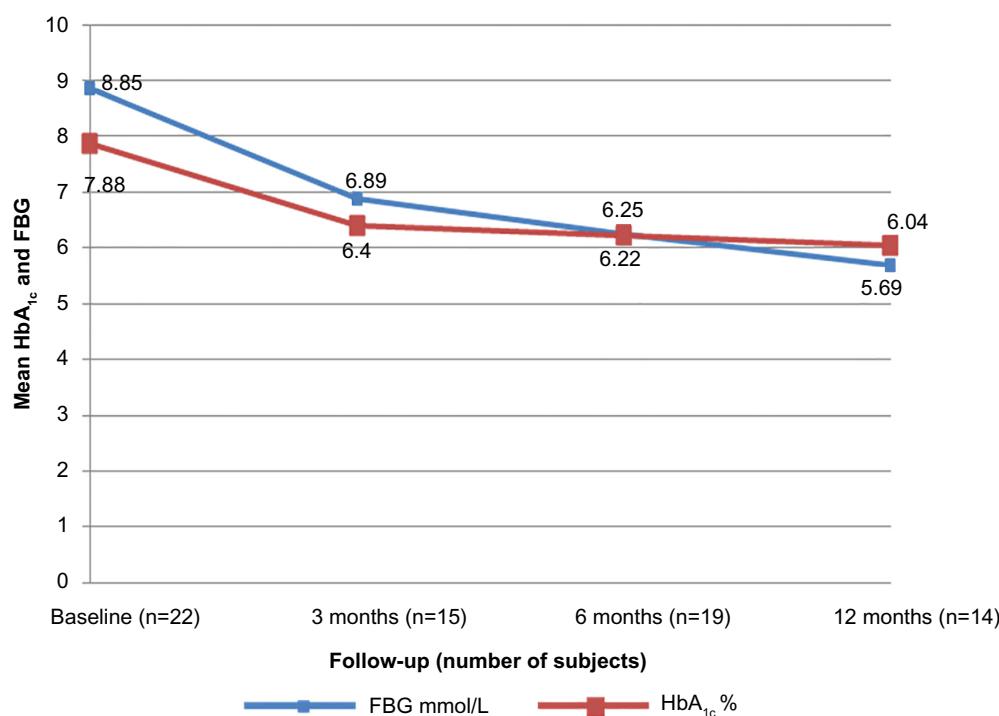


Figure 5 Postoperative changes in mean HbA_{1c} and FBG in patients with type 2 diabetes at various times. HbA_{1c} and FBG levels both decreased significantly ($P<0.005$) at 6 and 12 months.

Abbreviations: FBG, fasting blood glucose; HbA_{1c}, glycated hemoglobin.

The baseline demographics of the population studied here are similar to those reported internationally in terms of BMI (45.99 kg/m²) and sex (71% women), and the patients studied were younger (32.96 years) than those included in a meta-analysis on bariatric outcome which had 136 studies (BMI 46.85 kg/m², 72.6% women, mean age 38.97 years).²⁰ However, the 68% EWL found here was higher than the average% EWL reported by the latter review (61.56%, n=4,204) for the RYGB procedure.²⁰ This might be due to their inclusion of both short-term (<2 years) and long-term (>2 years) outcomes, whereas our study reports results covering a maximum of 12 months. Looking at similar short follow-up studies, our results fell within the wide range observed. Percentage EWLs of 51.3% (n=24), 60.5% (n=16), and 64.3% (n=111),²¹ and 86% (n=75)²² were reported after laparoscopic RYGB.

Other important findings of our study included the changes in body composition that followed the laparoscopic RYGB procedure. One of the main goals of any weight loss intervention is to reduce excessive body fat mass, which is related to metabolic disorders, and also to minimize the loss of fat-free mass that might be undesirable, although inevitable, with drastic weight loss interventions.²³ In our study, we reported a fat mass loss of 46% 12 months after RYGB, a value that is similar to those observed by others,

including Ciangura et al²⁴ (45.2%, n=42) and Tamboli et al²⁵ (50%, n=29).

In terms of the contribution of fat-free mass to body weight loss, our study reported similar fat-free mass loss to that reported by Das et al²⁶ (21% of total weight loss) and a lower loss of fat-free mass than that reported by Ciangura et al²⁴ (27% of total weight loss) or by Chaston et al²³ (an average of 31.3% of total weight loss); the time points were not consistent among the studies included in the latter review.

Consensus is lacking in the literature regarding the level of loss of fat-free mass that is considered excessive in terms of undesirable metabolic outcome.²³ However, the percentage of fat-free mass loss observed in our study was not associated with significant changes in post-surgery albumin levels, an indicator of clinical malnutrition. To minimize loss of fat-free mass after surgery, all of our patients underwent frequent follow-up visits with the clinical dietitian, following the post-bariatric surgery protocol; during these visits, recommendations concerning the importance of a well-balanced diet and sufficient protein were routinely reinforced.

The changes in comorbidity parameters observed here are consistent with the findings of many studies which document an improved lipid profile post-RYGB surgery, either through decreased total serum cholesterol, triglyceride, and low-

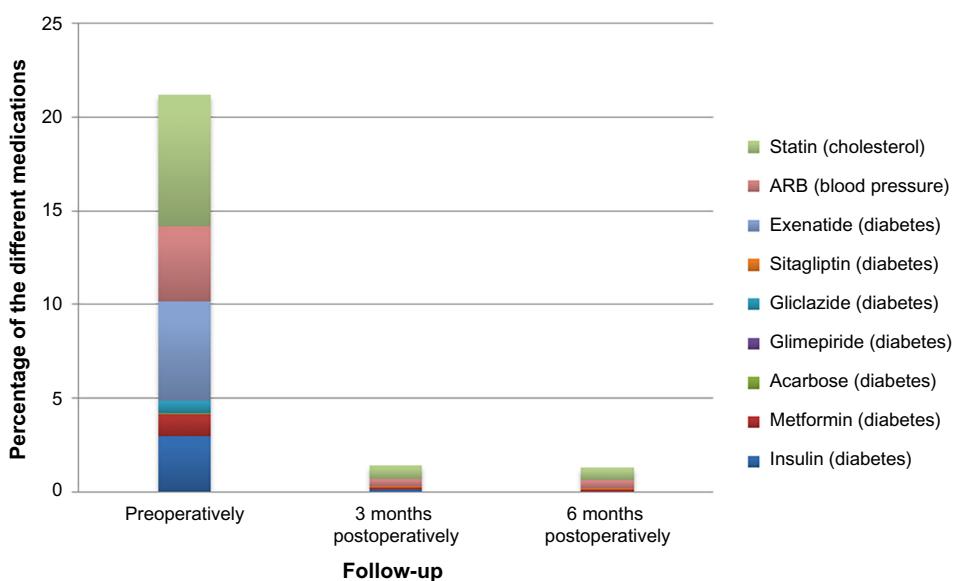


Figure 6 Changes in medication used by patients with diabetes after RYGB.

Notes: At 6 months postoperatively, the use of antidiabetic medications had dramatically decreased. The use of biguanides (metformin) and sulfonylureas (gliclazide) decreased by 89.2% and 88.88%, respectively. Glucagon-like peptide-1 agonists (exenatide) and insulin were stopped completely. Additionally, use of antihypertensive (ARB) and cholesterol-lowering (statin) medications both decreased by 90%.

Abbreviations: ARB, angiotensin receptor blocker; RYGB, Roux-en-Y gastric bypass.

density lipoprotein levels or through increased high-density lipoprotein levels.^{27,28} Improvements in the lipid profile arguably reduce cardiovascular risk after surgery. Indeed, such improvements were considered to significantly reduce 10-year cardiovascular risk according to the Framingham risk equation from 6.7% to 5.4% at the 12-month follow-up post-RYGB surgery.²⁹ Similarly, for type 2 diabetes, our results demonstrated a complete remission rate of 39% by 12 months after surgery and a dramatic improvement (74%) in HbA_{1c}. Our results are consistent with those of Pournaras et al,³⁰ who reported a 40.6% remission in type 2 diabetes (n=160) post-gastric bypass surgery in three bariatric centers.

Several studies have used different remission/resolution definitions for type 2 diabetes, possibly contributing to the variance in rates observed in the literature. We used the American Diabetes Association definition of complete remission of type 2 diabetes,¹⁴ which can yield lower remission rates. For instance, Hall et al³¹ reported a higher rate of type 2 diabetes resolution (68.4%, n=67), whereas Mingrone et al³² observed 75% (n=20) remission after RYGB. Despite these differences and due to the dramatic improvement in glycemic control observed here, our results add to the evidence supporting use of laparoscopic RYGB as an effective treatment for obese patients with type 2 diabetes (based on results obtained shortly after the operation) that can drastically decrease the need for antidiabetic medication. The elevated aspartate transaminase and

alanine transaminase levels observed at baseline in our patients might indicate a history of liver abnormalities, particularly nonalcoholic fatty liver disease, for which a significant reduction has been demonstrated post-surgery. However, the use of liver test values for the diagnosis of liver disease has limitations and can be considered a poor predictive diagnostic tool.³³ We also observed reductions in systolic and diastolic blood pressures, consistent with other reports that describe reductions in blood pressure post-RYGB;^{32,34} however, diastolic blood pressure was not significantly reduced. One reason for the latter finding might be that the average diastolic blood pressure was within the normal range at baseline.

Collectively, the results of bariatric surgery observed at this center, particularly those for laparoscopic RYGB, achieved dramatic weight loss and improved metabolic markers in the short term. Our results also replicate bariatric surgery results observed internationally.

Considering the economic burden of obesity and its comorbidities on the Emirati health care system, bariatric surgery is an increasingly attractive treatment for obesity and type 2 diabetes due to its ability to reduce associated health care costs. Indeed, it is evident from the literature that bariatric surgery is superior to conventional weight loss treatment in terms of reducing health care costs, increasing associated health benefits, and adding to patients' quality of life.^{35,36} More particularly, laparoscopic RYGB, the main

bariatric surgery performed at our center, is superior to other procedures (such as gastroplasty, jejunointestinal bypass, and open RYGB) in terms of the occurrence of complications, weight loss, and comorbidity outcomes.³⁷

Limitations

One of the main limitations of this study is its retrospective design; such designs are associated with selection bias due to a lack of randomization. Furthermore, potential confounders were not properly accounted for due to the study type and the homogeneity of the subjects. Additionally, the data were retrieved retrospectively; therefore, inaccuracies in data collection were inevitable. However, our data were collected in an evidence-based bariatric program by trained personnel, possibly increasing the accuracy of the data entries. Sleeve gastrectomy was also performed; however, due to the small number of patients who underwent this procedure, we were not able to elaborate on its results or compare it with laparoscopic RYGB outcomes.

Our results were similar to international outcomes in the short term; however, collection of long-term data is warranted to determine whether Emiratis maintain a trend similar to that shown in other countries (international data show maximum weight loss at 1–2 years after surgery and a subsequent increase in weight in the following years, although the weight gain has been reported to level off after 8–10 years).⁸ Despite the positive results following from bariatric surgery and its advantages over conventional treatment, it is important to mention that surgery cannot be offered to all patients who suffer from obesity. Hence, nonsurgical treatment involving dietary intervention, physical activity, and behavioral therapy should remain the first line of treatment for severely obese patients. Nevertheless, reporting on bariatric outcomes and studying the physiological changes caused by surgery might lead to better treatments of obesity and type 2 diabetes.

Acknowledgments

The authors would like to acknowledge the adjacent Sheikh Khalifa Hospital for their collaboration in performing the surgeries. They also thank the Global Health Partner Diabetes Center UAE for their support in establishing the bariatric clinic.

Author contributions

Salah Abusnana, Sarah Abdi, and Almantas Maleckas participated in the design of the study. Salah Abusnana, Sarah Abdi, Brigitte Tagure, Murtada Elbagir, and Almantas Maleckas collected the data. Salah Abusnana and Sarah Abdi analyzed

the data. Salah Abusnana and Sarah Abdi wrote the paper. Salah Abusnana and Almantas Maleckas had the primary responsibility for the final outcome and provided overall supervision. All authors made substantial contributions to conception and design, acquisition of data, or analysis and interpretation of data; took part in either drafting the article or revising it critically for important intellectual content; gave final approval of the version to be published; and agree to be accountable for all aspects of the work.

Disclosure

The authors report no conflicts of interest in this work.

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