Original Article

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Metabolic changes after bariatric surgical procedures

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ABSTRACT

Introduction: Obesity is associated with diabetes, dyslipidemia and increased cardiovascular disease risks. Bariatric surgeries are one of the most reliable ways to treat obesity. Bariatric Surgical procedures started in Basra at 2009 and since then, thousands of surgeries had been made, mainly in Al-Sadr Teaching Hospital.

Objective: To prospectively evaluate the short term effect of bariatric surgical procedures on body mass index (BMI), lipid profile and glycosylated hemoglobin (HbA1C) and compare the effects of various types of these surgical procedures.

Methods: A 12-month prospective study on 73 patients who underwent three types of bariatric surgeries, laparoscopic sleeve gastrectomy surgery (LSG), laparoscopic REUX-EN-Y gastric bypass surgery (LRYGB) and minigastric bypass surgery (MGB). Body mass index (BMI), HbA1C, total cholesterol (TC), High-Density-Lipoprotein cholesterol (HDL), Low-Density-Lipoprotein cholesterol (LDL) and triglycerides (TG) levels were evaluated before surgery and at 3 and 6 months postoperatively.

Results: All bariatric procedures show significant improvement in all parameters (increment in HDL, reduction in BMI, A1C, HDL, LDL, TC, TG) at 3 months that continue to improve more at 6 months postoperatively ($p<0.001$), however, bypass surgeries (LRYGB and MGB) has additional favorable independent effect on A1C and LDL seen at 6 months post operatively.

Conclusion: All of the studied bariatric surgeries improve BMI, HbA1C and lipid profile significantly, however, bypass procedures have more effect on LDL and HbA1C that seem to be procedure related and independent from weight loss or other changes.

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INTRODUCTION

Obesity is a complex, multifactorial, and largely preventable disease [(1)], affecting, along with overweight, over a third of the world's population today . [(2)] The prevalence of obesity in adults has been increasing in all countries. In 2014, 39% of adults aged 18 years and older (38% of men and 40% of women) were overweight. [(3)] Worldwide obesity has nearly tripled since 1975 and in 2016, more than 1.9 billion adults, 18 years and older, comprising 39% of adult population, were overweight. Of those, over 650 million (13%) of adults, were obese. [(4)]Most of the world's population live in countries where overweight and obesity kills more people than underweight. [(4)]

Iraq obesity prevalence increased from 11.9% on 1975 to 30.4% on 2016 while overweight prevalence was 35.9% at 1975 and became 59.8% at 2016. [(5)]

In a study conducted in Basrah from 2003 to 2010. overall overweight and obesity affects 55.1% of the population (54.7% of women and 45.3 % of men). Overweight was seen in 31.3% (50.2% of them men and 49.8% of women) with no significant gender differences. The overall prevalence of obesity was 23.8%. It is more in women than men (61.1% of them women and 38.9% of men. [(6)]

Body mass index (BMI) is a simple index of weight-for-height that is commonly used to classify overweight and obesity in adults. It is defined as a person's weight in kilograms divided by the square of his height in meters (kg/m2), [(4)] it provides the most useful population-level measure of overweight and obesity as it is the same for both sexes and for all ages of adults. However, it should be considered a rough guide because it may not correspond to the same degree of fatness in different individuals. [(4)]The WHO regards a BMI of less than 18.5 as underweight and may indicate malnutrition, an eating disorder, or other health problems, while a BMI equal to or greater than 25 is considered overweight and above 30 is considered obese. [(7)] (Table 1)

Epidemiologic studies have identified high BMI, as a risk factor for an expanding set of chronic diseases, including cardiovascular disease, [(8,9)] diabetes mellitus, chronic kidney disease, [(8)] many cancers, [(10)] and an array of musculoskeletal disorders. [(11,12)] Individuals with morbid obesity or BMI≥30 have a 50-100% increased risk of premature death compared to individuals of healthy weight, [(13)] and on 2013, the American Medical Association designated obesity as a chronic disease and not a simple life style. [(14)] It is estimated that 60 t0 70 % of obese individuals are dyslipidemic with a positive correlation between severity of obesity and dyslipidemia, [(15)] lipid abnormalities in obese persons include increase TG levels, increased TC, normal to increased LDL and depressed level of HDL. [(15)] These lipid changes are listed by AHA as modifiable risk factors for CAD and atherosclerosis. [(16)] The CVDs are now the leading cause of death globally. [(17)] And modest reduction in body fat (5 to15%) improve dyslipidemia and cardiovascular risk factors. [(18)]

The first surgical procedure performed specifically for weight loss took place in 1954, [(19)] and since then, bariatric procedures have become less invasive and safer, and insights regarding the beneficial metabolic effects of such procedures have led to additional indications for these procedures. Now bariatric surgical procedures are considered the most effective way of reducing weight in individuals with obesity, and clinical trials also show it improve adiposopathy (pathogenic adipose tissue) and dyslipidemia. [20-22] Metabolic surgery reduces the risk of CVD. [23]

There are different types of bariatric surgeries currently available including laparoscopic sleeve gastrectomy (LSG), one anastomosis gastric bypass or mini gastric bypass (MGB), laproscopic Roux-en-Y gastric bypass (LRYGB), laparoscopic adjustable gastric band (LAGB), biliopancreatic diversion with duodenal switch.

Among various bariatric procedures, laparoscopic sleeve gastrectomy (LSG) has rapidly gained popularity to become most frequently performed worldwide. [24,25] LSG was initially regarded as a purely restrictive procedure, we now know that it also promotes weight loss by inducing anorexia through removal of the majority of ghrelin-producing cells located in the gastric fundus. [26] it is a vertically oriented gastrectomy that removes approximately 70 to 80 percent of the greater curvature of the stomach, resulting in the creation of a narrow gastric tube with a volume of approximately 150 to 200 mL based on the less distensible lesser curvature. [27] The remnant stomach after LSG is referred to as a sleeved stomach or simply "sleeve."

laparoscopic Roux-en-Y gastric bypass surgery (LRYGB), a restrictive and malabsorptive technique in which a gastric pouch is created by completely separating stomach from gastric remnant and anastomosed to the jejunum. An entero-entero anastomosis is created between the alimentary limb and pancreatobiliary limb. The intake of food is restricted by gastric pouch and nutrient absorption is reduced by bypassing the duodenum and part of the jejunum. [28-30]

In recent years, a surgical technique known as single-anastomosis gastric bypass (SAGB) or mini-gastric bypass (MGB) has been developed; its frequency of performance has increased considerably in the current decade. [31] Initially described by Rutledge, [31] this procedure proposes a simplification of Roux-en-Y bypass by performing a single anastomosis, with a significant reduction of technical complexity, shorter operative time and a potential reduction in morbidity and mortality.Several studies have demonstrated the benefits provided by this procedure, including excess weight loss and resolution of comorbidities equivalent or even higher than those observed after the Roux-en-Y gastric bypass. [32-34]

In Basrah, 1st bariatric surgery done in Al-Sadr Teaching Hospital in 2012. And since then, more than 2900 surgery had been done.

The aim of study is to evaluate the short term changes in BMI, lipids parameters and HbA1C after bariatric surgeries in Al-Sadr Teaching Hospital for patient with morbid obesity who underwent these surgeries and to compare the differences of effect of these surgeries on those parameters.

PATIENTS AND METHODS

A prospective cohort study was conducted in Al-Sadr Teaching Hospital in Basrah for morbidly obese patients who underwent bariatric surgical procedures from the first of January 2018 to the end of June 2018.

Initially the study included 150 patients, the whole number of patients underwent bariatric surgical procedures during the specified period, however, many of them lost from the study either because they met the exclusion criteria or more commonly, they didn’t accept to participate or investigation before surgery couldn’t be withdrawn on time. This decrease the study size to 73 patients, their BMIs were more than 40, or more than 35 and associated with obesity related morbidities. Forty for patients of them were females, their mean age was 38.4 ±5 year and range from 21 to 57 year. Their BMI ranged from 38 to 63 and mean BMI was 48.7± 5. 19 patients (26%) were diabetic and 22 (30%) were hypertensive (Table 2,3).

They were subjected to different types of surgical procedures, 48 patient have LSG surgery,11 patient has LRYGB surgery, and 14 patients has MGB surgery.

Before surgery, history was taken for every patient, including chronic diseases and medication uses. Weight and height was measured and BMI calculated and beside the routine preoperative evaluation, blood samples in early morning after 8 to 12 hour fasting and serum sent for measuring HbA1C, HDL, LDL, TC and TG. The samples analyzed using COBAS Integra 400 Plus device by enzymatic colorimetric tests for lipids and turbidometric principle for HbA1C.The patients then followed up at 3 months and 6 months postoperatively for reevaluating their BMI and repeating the measuring of HBA1C and lipid profile.

Our exclusion criteria were those unwilling to participate in the study, those on statin or other lipid lowering therapy, diabetic who were on insulin, preceding history of another bariatric surgery, non-compliant patient for follow up, other endocrine abnormalities other than diabetes or dyslipidemia (like thyroid problems, cushing syndrome, or pituitary problems like acromegaly or hyperprolactinemia.).

Statistical analysis

Data were tested using the IBM SPSS statistical software version 20 for windows for analysis

1-Descriptive statistics.

2-Paired sample T test.

3-ANOVA (analysis of variance).

4-Multivariate linear regression analysis.

Using descriptive statistics, we expressed continuous variables (age, BMI, HbA1C, HDL, LDL, TC and TG) as mean ±SD and categorical variables (gender, procedure type, diabetes state and hypertensive state) as frequencies and percentage.

To avoid the possible effect of the baseline values of the metabolic parameters (BMI, A1C, HDL, LDL and TG) on the changes during the follow up periods, we measure the % of changes from the baseline (Δ%) for each parameter at 3 and 6 months follow up and depend mainly on that Δ%% in the next statistical comparisons.

Then we used paired sample T test to analyses differences (pure values and percentage of changes from the baseline) in the same continuous variables over time.

Then We used one-way ANOVA followed by post hoc LSD test to see if there are significant differences among changes in the studied parameters according to procedure type.

To adjust for all the other variables, multivariate analyses were performed with % of changes (in each of (BMI, A1C, HDL, LDL, TC and TG) as dependent variables, and with (age, gender, type of surgery, baseline values of BMI, A1C, each lipid profile and simultaneous % of changes of all the studied parameters) as independent variables.The results in this study were considered statistically significant only when p value <0.05.

RESULTS

Following up all patients at 3 months postoperatively, there was highly significant ($p<0.001$) improvement in all parameters of the study (decrement in BMI, HbA1C, LDL, TC, TG and increment in HDL) regardless of type of surgical procedure. As compared to baseline, the BMI decreased by 8.5±1.8 (17±3 percentages), A1C decreased by 0.6±0.6 (9±7 percentages), HDL slightly increased by 1.9±1 (4±2 percentages), LDL decreased by 16.4±10 (11±7 percentages), TC decreased by 18.7±8.5 (9±2 percentages), and TG decreased by 19.2±17 (12±6 percentages) (Table 4).

All of these changes continue to significantly improve further more ($p<0.001$) at 6 months follow up. Regardless of procedures type, as compared to the baseline values, BMI now decreased by 13.8±2.6, (28±0 percentages), A1C decreased by 0.9 ± 0.9(13±9 percentages), HDL increased by 4.3±1.8 (9±3 percentages), LDL decreased by 28. ±12.6 (20±7 percentages), total cholesterol decreased by 39.8±12.8 (20±10 percentages), and TG decreased by 33.9±20.5 (22±6 percentages) (Table 4).

These changes were different to some extents according to the type of procedure. Some of these differences were statistically significant. (Fig.1)

For BMI, at three months post operatively, as compared to the baseline, it decreased significantly by 17% for LSG surgery, by 18% for LRYGB surgery, and by 19% for MGB surgery($p<0.001$) (Table 5), with only statistical significance between LSG and MGB procedures (Table 9). While at 6 months postoperatively, also as compared to baseline, BMI decreased also significantly by 27% for LSG surgery, 31% for LRYGB surgery, and 30% for MGB surgery ($p<.001$) (Table 6). With statistical significance only between LSG and LRYGB procedures ($P=0.02$) (Table 10).

For HbA1C, at three months post operatively, as compared to the baseline, it decreased significantly by 7% for LSG surgery, by 10% for LRYGB surgery, and by 12% for MGB surgery($p<0.001$) (table 5), however, there was no statistical significance of changes among the three procedures ($p>0.05$) (Table 7). While at 6 months postoperatively, HbA1C decreased, as compared to the baseline values, by 11% for LSG, 17% for LRYGB, and 18% for MGB surgeries. There was statistical significance only between LSG and LRYGB and between LSG and MGB, with ($p = 0.036$) and ($p = 0.009$), respectively (Table 10).

For HDL, it increased at 3 months postoperatively, as compared to baseline, by 3% for LSG, 6% for LRYGB, and 7% for MGB surgeries, there was statistical significance only between LSG and LRYGB and LSG and MGB, with $P<0.001$ for both (Table 9). However, this differences' significance is lost 6 months postoperatively, with ($p>0.05$) (Table 8).

For LDL, it decreased significantly at 3 months, as compared to baseline, by 12% for LSG, by 11% for LRYGB, and by 13% for MGB ($p<0.001$) (table 5), however, there was no statistically significant differences among the different surgical procedures ($p>0.05$) (Table 9). At 6 months postoperatively, LDL decreased, as compared to the baseline values, by 20% for LSG, 21% for LRYGB, and 23% for MGB surgeries and statistical significance was only founded between LSG and MGB, with ($P=0.008$) (Table 10).

For TC, it decreased significantly at 3 months, as compared to baseline, by 9% for LSG,by 8% for LRYGB, and by 11% for MGB ($p<.001$)

(table 5). At 6 months, it significantly decreased, as compared to baseline, by 18% for LSG, by 25% for LRYGB, and by 19% for MGB (p<.001) (table 6) there was no statistically significant differences among the different surgical procedures at 3months (Table 7) and at 6 months (Table 8), with p value>0.05.

For TG, at three months postoperatively, it decreased significantly from the baseline by 11% for LSG surgery, by 12 % for LRYGB surgery, and by 16% for MGB surgery (p<.001) (table 5). Statistical significance was noted only between LSG and MGB procedures(P=0.008) (Table 9), while at follow up 6 months postoperatively, as compared to baseline, TG significantly decreased by 20% for LSG, and by 25% for both LRYGB and MGB (p<.001) (table 6). Statistical significance was found when comparing LSG changes with either LRYGB (p =.01) or with MGB(p=009) (Table 10).

However, after doing multivariate regression analysis (Table 11,12), procedure's type by itself, independent of all other changes, was only significantly correlated with HDL changes at 3 months (B=0.024, p<0.003, with A1C changes 6 months (B=0.024, p=0.013) follow up, and with LDL at 6 months follow up (B=0.017, p=0.031). there was no pure effect of procedure type on other parameters differences mentioned above.

DISCUSSION

This is the first study, according to our best knowledge, that was conducted in Basrah to follow changes in some metabolic parameters (in form of BMI, HbA1C, HDL, LDL, TC and TG) after bariatric surgical procedures.

The study shows improvement in all parameters (reduction in BMI, A1C, LDL, TC, TG and increment in HDL) at 3 months that continue to improve furthermore by 6 months follow up in all patients, regardless of procedure type, these changes were similar to the previous literatures and considered associated with theoretical reduction in CVDs risks. [35-37]

While moving to the effect of each types of the three surgical procedures studied, there was no statistical difference when comparing any of the changes of LRYGB and those of MGB, this is comparable to a study by Wei-Jei Lee. [37]

And by Maher El Chaar. [38] and other studies that shows comparable outcomes for both of those bypass procedures.

however, when comparing LSG with either LRYGB or MGB, and after multivariate regression analysis, both bypass procedures were favorably, and independently, affecting significantly HbA1C change at 6 months, they also independently and favorably affect LDL changes after 6 months, however the LDL changes were statistically significant for MGB only, since there are no statistically significant differences between MGB and LRYGB, this may be due to statistical issues related to the small sample size. They also favorably affect HDL changes at 3 months but not at 6 months.

This independent effect of bypass procedures on A1C and LDL and suggest both have additional metabolic effect other than weight loss, [39] which is suggested by many authors due to the frequent observation of rapid improvement in glucose levels and insulin sensitivity before even weight loss took place. [40]

While our study shows no pure effect of procedure's type neither on HDL changes at 6 months, nor on BMI, TC or TG at any time of our study.

Limitation of study

1-Short duration of study so we couldn't follow up patients after 6 months.

2-Small sample size.

These factors may affect outcome of study and make the reliability of our results in question.

CONCLUSIONS

All the studied bariatric surgeries (LSG, LRYGB and MGB) decrease BMI, improve all lipid profiles (increase HDL, decrease LDL, TC and TG), and decrease HbA1C significantly on the short term. So they all theoretically have a favorable short term effect on CVDs risk.

Both bypass procedures (MGB and LRYGB) have better outcome on BMI, HbA1C and TG than LSG procedures on the short term follow up and they have additional effect on HbA1C appear to be due to the surgical procedure itself, not just because of weight loss.

MGB surgery has better outcome than LSG surgery regarding LDL at short term and this effect appear to be related to the surgical procedure itself and independent from weight loss and other changes.

Changes in TC and HDL are similar among all the three surgical procedures.

RECOMMENDATIONS

Doing longer follow up studies at 1-year post op and ahead with larger sample size to see the progression and/or maintenance of lipid and A1C changes for the patients.

Doing more specific studies to compare between the metabolic effects of different metabolic surgeries.

Although need larger studies with longer duration, but we advised that morbidly obese patient with uncontrolled diabetes and/or high level of LDL, better to be offered a MGB surgical procedure.

Table 1: classification of body weight according to BMI by the WHO. [7]

Category	BMI (kg/m2)	
	from	to
Very severely underweight		15
Severely underweight	15	16
Underweight	16	18.5
Normal (healthy weight)	18.5	25
Overweight	25	30
Obese Class I (Moderately obese)	30	35
Obese Class II (Severely obese)	35	40
Obese Class III (Very severely obese)	40	45
Obese Class IV (Morbidly Obese)	45	50
Obese Class V (Super Obese)	50	60
Obese Class VI (Hyper Obese)	60	

Table 2: general demographic and medical characteristics of the studied patients

		Procedure type						Total	
		LSG		LRYGB		MGB			
		N	%	N	%	N	%	N	%
Age	under30	9	18.8	0	0.0	1	7.1	10	13.7
	30-39	28	58.3	5	45.5	6	42.9	39	53.5
	40-49	9	18.7	4	36.4	6	42.9	19	26.0
	50-59	2	4.2	2	18.1	1	7.1	5	6.8
Total		48	100.0	11	100.0	14	100.0	73	100.0
Mean age		35.8±8.7		44.8±7.7		39.5±7.7		38.4±5	
Gender	Female	34	70.8	3	27.3	7	50	44	60.3
	Male	14	29.2	8	72.7	7	50	29	37.7
Total		48	100.0	11	100.0	14	100.0	73	100.0
Diabetes state	DM	8	16.7	5	45.5	6	42.9	19	26
	NO DM	40	83.3	6	54.5	8	57.1	54	74
Total		48	100.0	11	100.0	14	100.0	73	100.0
Hypertensive state	HTN	8	16.7	6	54.5	8	57.1	22	30.1
	NO HTN	40	83.3	5	45.5	6	42.9	51	69.9
Total		48	100.0	11	100.0	14	100.0	73	100.0

Table 3: Selected indicators of patient profile by type of surgical procedure

	LSG M±SD	LRYGB M±SD	MGB M±SD
BMI	46.5±4	54.4±4.5	51.7±4.8
HbA1C	5.4±1.6	6.6±1.9	6.4±2.3
HDL	46.2±8.4	42.8±6.9	45.2±5.7
LDL	131.9±44.4	131.7±20.4	147.2±40
CHOL	197.2±44.2	193.7±14.9	210.9±41.2
TG	139.9±41.2	154.5±48.2	173.4±53.9
TOTAL	48	11	14

Table 4: Overall changes in selected profile indicators regardless of surgical procedure's type

	baseline	3 months after surgery			6 months after surgery		
	mean± SD	mean± SD	mean change±SD	Δ change%±SD	Mean±SD	mean change±SD	Δ change%±SD
BMI (N=73)	48.7±5.2	40.2±4.3	-8.5±1.8	-17±3	34.8±4	-13.8±2.6	-28±
A1C (N=73)	5.7±1.8	5.2±1.3	-.6±. .6	-9±7	4.9±1	.9±.9	-.13±9
HDL (N=73)	45.5±7.8	47.4±8	1.9±1	4±2	49.8±8.6	4.3±1.8	9±3
LDL (N=73)	134.8±40.9	118.4±34.1	-16.4±10	-11±7	106.8±31.8	28±12.6	-20±7
TC (N=73)	199.3±40.6	180.6±34	-18.7±8.5	-9±2	159.4±4	39.8± 12.8	-19±1
TG (N=73)	148.5±46.1	129.3±35.8	-19.2±17	-12±6	114.7±40	-33.9±20.5	-22±6

P value <.001 for all changes

Table 5: ANOVA analysis for changes in selected profile indicators at 3 months post operatively according to the type of surgery

Procedure		Δ A1C3%	Δ BMI3%	Δ HDL3%	Δ LDL3%	Δ CHOL3%	Δ TG3%
LSGB	Mean	-7	-17	+3	-12	-9	-11
	SD	6	2	1	4	2	7
	N	48	48	48	48	48	48
LRYGB	Mean	-10	-18	+6	-11	-8	-12
	SD	6	2	1	3	1	4
	N	11	11	11	11	11	11
MGB	Mean	-12	-19	+7	-13	-9	-16
	SD	7	4	.2	3	3	2
	N	14	14	14	14	14	14
Total	Mean	-9	-17	+4	-12	-9	-12
	SD	7	3	2	4	2	6
	N	73	73	73	73	73	73

P value <.001 for all changes

Table 6: ANOVA analysis for % of variation in changes in selected profile indicators at 6months post operatively according to the type of surgery

Procedure		Δ A1C6%	Δ BMI6%	Δ HDL6%	Δ LDL6%	Δ CHOL6%	Δ TG6%
LSGB	Mean	-11	-27	+10	-20	-18	-20
	SD	7	3	1	5	4	6
	N	48	48	48	48	48	48
LRYGB	Mean	-17	-31	+9	-21	-25	-25
	SD	9	6	6	5	25	5
	N	11	11	11	11	11	11
MGB	Mean	-18	-3	+9	-23	-19	-25
	SD	11	4	.05	36	6	5
	N	14	14	14	14	14	14
Total	Mean	-13	-28	+9	-20	-19	-22
	SD	9	4	3	5	10	6
	N	73	73	73	73	73	73

P value <.001 for all changes

Table 7: One-way ANOVA test for variation in changes in selected profile indicators at 3 months postop follow up according to procedure's type.

		Sum of Squares	df	Mean Square	F	P value
Δ A1C3%	Between Groups	.025	2	.012	3.075	.052
	Within Groups	.281	70	.004		
	Total	.306	72			
	Within Groups	.496	70	.007		
	Total	.566	72			
Δ BMI3%	Between Groups	.008	2	.004	5.791	.005
	Within Groups	.050	70	.001		
	Total	.058	72			
	Within Groups	.108	70	.002		
	Total	.118	72			
Δ HDL3%	Between Groups	.023	2	.011	47.513	.000
	Within Groups	.017	70	.000		
	Total	.040	72			
	Within Groups	.083	70	.001		
	Total	.085	72			
Δ LDL3%	Between Groups	.002	2	.001	.666	.517
	Within Groups	.094	70	.001		
	Total	.096	72			
	Within Groups	.140	70	.002		
	Total	.155	72			
Δ CHOL3%	Between Groups	.001	2	.001	1.124	.331
	Within Groups	.036	70	.001		
	Total	.038	72			
	Within Groups	.757	70	.011		
	Total	.792	72			
Δ TG3%	Between Groups	.025	2	.012	3.725	.029
	Within Groups	.234	70	.003		
	Total	.259	72			
	Within Groups	.252	70	.004		
	Total	.295	72			

Table 9: post hoc LSD test for variation in changes in selected profile indicators at 3months postop follow up according to procedure's type

Dependent Variable	(I) procedure	(J) procedure	Mean Difference (I-J)	Std. Error	P value.	95% Confidence Interval	
						Lower Bound	Upper Bound
Δ BMI3%	LSGB	LRYGB	.01311	.00891	.146	.0309	-.0047
		MGB	.02676*	.00810	.001	.0429	.0106
	MGB	LSGB	-.02676*	.00810	.001	-.0106	-.0429
		LRYGB	-.01365	.01074	.208	.0078	-.0351
Δ A1C3%	LSGB	LRYGB	.02844	.02118	.184	.0707	-.0138
		MGB	04457*	.01924	.023	.0829	.0062
	MGB	LSGB	-.04457*	.01924	.023	-.0062	-.0829
		LRYGB	-.01613	.02553	.530	.0348	-.0670
Δ HDL3%	LSGB	LRYGB	-.03066*	.00518	.000	-.0203	-.0410
		MGB	-.04140*	.00471	.000	-.0320	-.0508
	MGB	LSGB	04140*	.00471	.000	.0508	.0320
		LRYGB	.01074	.00624	.090	.0232	-.0017
Δ LDL3%	LSGB	LRYGB	.00285	.01227	.817	-.0216	.0273
		MGB	-.01180	.01115	.293	-.0340	.0104
	MGB	LSGB	.01180	.01115	.293	-.0104	.0340
		LRYGB	.01465	.01479	.325	-.0148	.0441
Δ CHOL3%	LSGB	LRYGB	.01037	.00763	.178	-.0048	.0256
		MGB	-.00235	.00693	.735	-.0162	.0115
	MGB	LSGB	.00235	.00693	.735	-.0115	.0162
		LRYGB	.01273	.00919	.171	-.0056	.0311
Δ TG3%	LSGB	LRYGB	-.00966	.01932	.619	-.0482	.0289
		MGB	-.04790*	.01755	.008	-.0829	-.0129
	MGB	LSGB	.04790*	.01755	.008	.0129	.0829
		LRYGB	.03823	.02328	.105	-.0082	.0847
*. The mean difference is significant at the 0.05 level.							

Table 10: post hoc LSD test for variation in changes in selected profile indicators at 6 months postop follow up according to procedure's type

Dependent Variable	(I) proceedure	(J) proceedure	Mean Difference (I-J)	Std. Error	Sig.	95% Confidence Interval	
						Lower Bound	Upper Bound
Δ BMI6%	LSGB	LRYGB	-.03098*	.01311	.021	-.0571	-.0048
		MGB	-.01946	.01191	.107	-.0432	.0043
	MGB	LSGB	.01946	.01191	.107	-.0043	.0432
		LRYGB	-.01152	.01580	.468	-.0430	.0200
Δ A1C6%	LSGB	LRYGB	-.06015*	.02814	.036	-.1163	-.0040
		MGB	-.06879*	.02557	.009	-.1198	-.0178
	MGB	LSGB	.06879*	.02557	.009	.0178	.1198
		LRYGB	.00864	.03392	.800	-.0590	.0763
Δ HDL6%	LSGB	LRYGB	-.00958	.01148	.407	-.0325	.0133
		MGB	-.01194	.01043	.256	-.0327	.0089
	MGB	LSGB	.01194	.01043	.256	-.0089	.0327
		LRYGB	.00236	.01384	.865	-.0252	.0300
Δ LDL6%	LSGB	LRYGB	-.01090	.01494	.468	-.0407	.0189
		MGB	-.03734*	.01358	.008	-.0644	-.0103
	MGB	LSGB	.03734*	.01358	.008	.0103	.0644
		LRYGB	.02644	.01801	.147	-.0095	.0624
Δ CHOL6%	LSGB	LRYGB	-.06207	.03476	.079	-.1314	.0073
		MGB	-.00771	.03159	.808	-.0707	.0553
	MGB	LSGB	.00771	.03159	.808	-.0553	.0707
		LRYGB	-.05436	.04190	.199	-.1379	.0292
Δ TG6%	LSGB	LRYGB	-.05300*	.02007	.010	-.0930	-.0130
		MGB	-.04928*	.01824	.009	-.0857	-.0129
	MGB	LSGB	.04928*	.01824	.009	.0129	.0857
		LRYGB	-.00372	.02419	.878	-.0520	.0445

*. The mean difference is significant at the 0.05 level.

Table 11: multivariate linear regression analysis for variation in changes in selected profile indicators at 3 months postop follow up.

	Δ BMI3%		Δ A1C3%		Δ HDL3%		Δ LDL3%		Δ TC3%		Δ TG3%	
	B	P	B	P	B	P	B	P	B	P	B	P
Age	.001	.183	-.001	.087	.000	.140	.000	.685	8.455E-005	.762	.000	.612
Gender	-.015	.115	.012	.434	-.008	.134	-.027	.011	.003	.617	.016	.367
DM	-.018	.268	.013	.612	.002	.832	-.035	.049	.033	.001	.062	.031
HTN	.008	.388	.015	.296	-.001	.786	-.011	.318	.018	.002	.017	.304
Procedure type	.013	.093	.032	.008	-.024	.000	-.005	.590	.003	.606	.024	.096
BMI	.002	.004	.001	.573	3.543E-006	.991	.001	.197	.000	.287	-.001	.321
A1C	.003	.373	.020	.001	-.004	.088	.008	.054	-.003	.212	-.006	.445
HDL	.000	.857	-.001	.200	.000	.251	-.001	.238	.000	.669	.002	.125
LDL	.000	.205	.000	.646	8.199E-005	.497	.000	.338	.000	.236	.000	.427
CHOL	.000	.223	.000	.306	1.013E-005	.939	7.140E-005	.787	.000	.053	.000	.478
TG	.000	.204	.000	.151	1.562E-005	.773	-5.903E-005	.583	.000	.064	.001	.000
Δ BMI 3	X	X	.021	.921	-.006	.934	.028	.851	.079	.363	.094	.700
Δ A1C3%	.008	.921	X	X	.097	.041	-.058	.547	-.011	.835	-.156	.313
Δ HDL3%	-.019	.934	.734	.041	X	X	-.333	.205	.125	.410	.421	.322
Δ LDL3%	.022	.851	-.111	.547	-.084	.205	X	X	.207	.005	.204	.341
Δ CHOL3%	.184	.363	-.067	.835	.096	.410	.632	.005	X	X	-.685	.063
Δ TG3%	.028	.700	-.114	.313	.041	.322	.078	.341	.063	.063	X	X
R squre(adjusted)	.975		.834		.889		.935		.963		.855	
Anova p value	.000		.000		.000		.000		.000		.000	

Table 12: multivariate linear regression analysis for variation in changes in selected profile indicators at 6 months postop follow up.

	BMI6		A1C6		HDL6		LDL6		CHOL6		TG6	
	B	P	B	P	B	P	B	P	B	P	B	P
Age	.000	.678	-.001	.145	.000	.657	.000	.553	.002	.183	.001	.315
Gender	8.266E-005	.995	.002	.890	-.007	.520	-.031	.010	-.030	.318	-.003	.856
DM	-.012	.607	-.016	.526	-3.180E-005	.999	-.031	.128	.025	.609	.017	.535
HTN	.006	.662	.008	.609	-.019	.080	-.006	.623	.044	.136	.012	.474
Procedure type	.008	.376	.024	.013	.008	.270	.017	.031	.009	.640	.013	.238
BMI	.003	.002	.000	.650	.000	.808	.002	.015	.002	.258	.001	.374
A1C	.008	.268	.038	.000	.000	.967	.009	.165	.001	.921	.000	.970
HDL	.001	.271	-.002	.133	.000	.793	-9.053E-005	.912	.000	.872	.001	.614
LDL	.000	.209	.000	.531	.000	.643	.000	.403	.001	.085	.000	.437
CHOL	.000	.373	.000	.519	.000	.256	.000	.459	-.001	.393	.000	.745
TG	.000	.241	.000	.333	.000	.004	-2.166E-005	.875	9.533E-005	.771	.001	.000
Δ BMI 3	X	X	-.019	.895	.074	.074	.760	.760	-.220	.432	.068	.672
Δ A1C3%	-.016	.895	X	X	.780	.780	.529	.529	.265	.292	-.131	.365
Δ HDL3%	-.303	.074	.053	.780	X	X	.136	.136	-.300	.407	.373	.068
Δ LDL3%	.046	.760	-.105	.529	-.172	.136	X	X	.798	0.10	.041	.820
Δ CHOL3%	-.049	.432	.073	.292	-.040	.407	.010	.010	X	X	.021	.781
Δ TG3%	.047	.672	-.110	.365	.153	.068	.820	.820	.065	.781	X	X
R squre (adjusted)	.976		.903		.886		.966		.824		.945	
ANOVA p value	.000		.000		.000		.000		.000		.000	

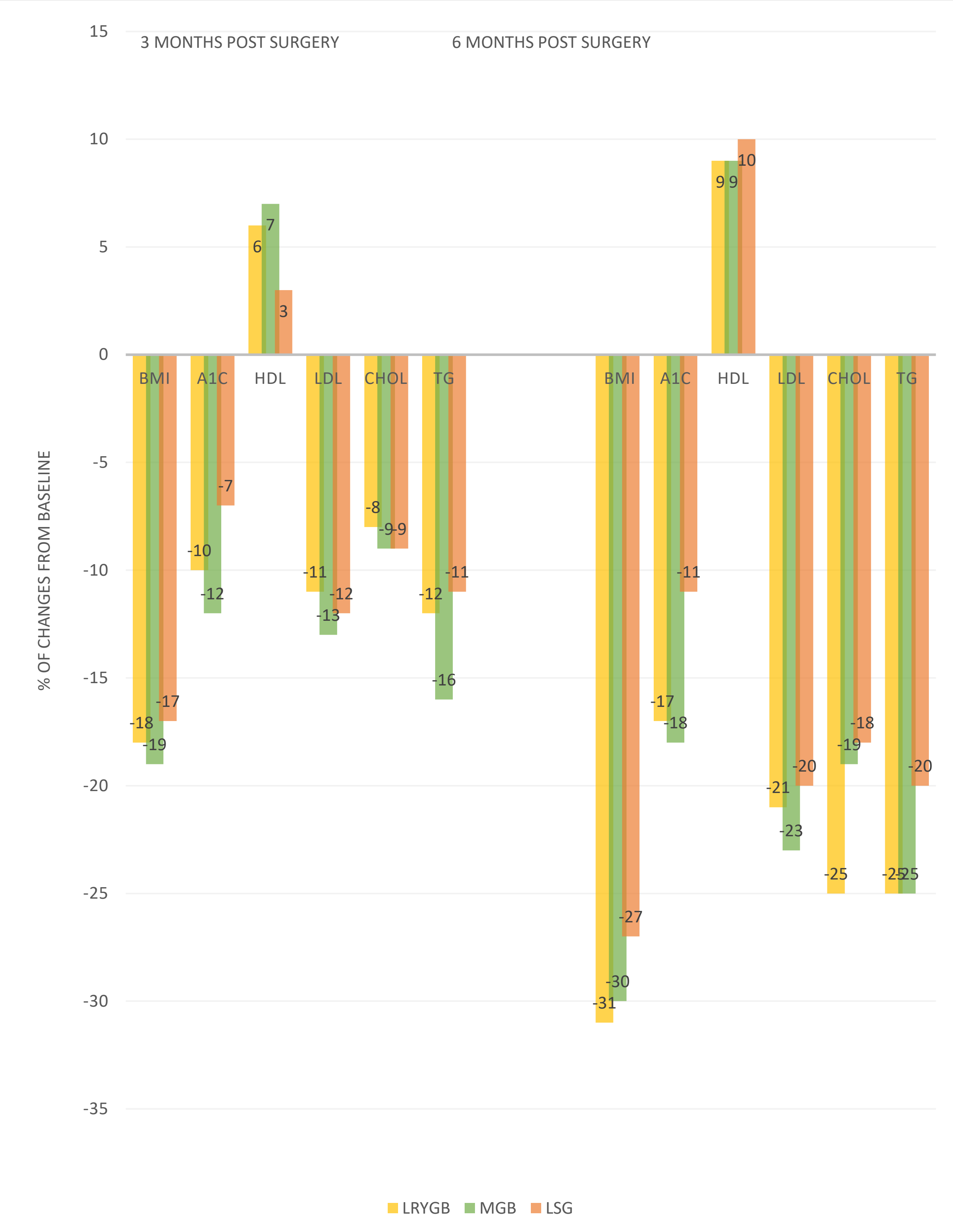

Figure 1: Percentage of changes (Δ%) from baseline values in selected profile indicators at different times of study

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