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High cardiovascular risk patients benefit more from bariatric surgery than low cardiovascular risk patients

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Abstract

Introduction Atherosclerotic cardiovascular disease (ASCVD) and Framingham risk scores (FRS) are used to calculate 10-year risk of coronary death, nonfatal myocardial infarction, or fatal/nonfatal stroke. Our goal is to evaluate the association between preoperative cardiovascular risk and weight loss.

Methods We retrospectively reviewed bariatric surgeries from 2010 to 2016. Patients who met criteria for calculating 10-year ASCVD score and FRS were included. Data collected included baseline demographics, perioperative parameters, and postoperative outcomes at 12 months. Simple linear regression and multiple linear regression models were applied to test influence of individual or multiple factors of interest on 12-month weight loss outcomes.

Results Of 1330 bariatric patients studied, 360 patients met criteria for ASCVD and FRS calculation. Sleeve gastrectomy (LSG) was the most prevalent surgery 63.05%, followed by Roux-en-Y gastric bypass (LRYGB) 20.55%, revision procedures 11.9%, and adjustable gastric banding (LAGB) 4.4%. Initial BMI was 42.71 ± 7.85 kg/m^2 for females and 42.72k ± 7.42 kg/m^2 for males, with a 12-month percentage of estimated BMI loss (%EBMIL) of 66.51% in females and 60.29% in males. Preoperative 10-year ASCVD score was higher in males than females with a 34.73% relative risk reduction (RRR) in males and 35.3% RRR in females at 12-month follow-up. Regarding FRS, preoperative risk was 33.13 ± 21.1% in males and 15.71 ± 14.52% in females, with an RRR of 25.8% in males and 32.2% in females. Univariate analysis of preoperative FRS and %EBMIL showed that for every percentage unit increase in the patient's preoperative FRS, %EBMIL decreases 0.31 percentile unit ($P < 0.001$). Furthermore, preoperative ASCVD score is also significantly associated with %EMBIL—for every percentage unit increase in preoperative ASCVD score, %EBMIL decreases 0.42 percentile credits.

Conclusion Study results suggest ASCVD and FRS are equally reduced after bariatric surgery, especially after LSG and LRYGB. Moreover, preoperative FRS and ASCVD risk score showed an inversely proportional relationship with %EBMIL loss at 12 months.

Keywords Bariatric surgery · Gastric bypass · Sleeve gastrectomy · Cardiac risk · Myocardial infarction · Morbid obesity

Weight loss surgery has become standard of care for morbidly obese patients with comorbidities or failure of weight loss with medical treatment [1]. The rise of bariatric surgery has been more pronounced in recent years due to the unstoppable obesity pandemic [2]. The effects of bariatric interventions are broad and not limited to weight loss, the complex metabolic changes after bariatric surgery being one of the most important aspects of this surgery [3–5].

Bariatric surgery has demonstrated to be highly successful in the remission of several comorbidities such as Type 2 diabetes mellitus, essential arterial hypertension, hypercholesterolemia, sleep apnea, and even decreasing the risk of certain types of obesity-related cancers [6–8]. Furthermore, the effect of bariatric surgery on cardiovascular risk has been well described, having an important role in halting the progression of cardiovascular diseases [9, 10].

Despite all the metabolic and multiorgan benefits of bariatric surgery, an ideal weight loss surgery is still defined and measured by the amount of weight loss a patient has in

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a specific period of time. The most accepted term for successful weight loss surgery is defined as an estimated BMI loss of more than 50% or total weight loss of more than 20% [11]. Most of the bariatric surgeries successfully achieve a significant amount of weight loss in a short period of time and results prevail long-term [12, 13]. However, due to its multifactorial nature, there are still a variety of aspects of the weight loss pattern that remain unknown, such as the reason for the failure of weight loss or weight regain [14]. Our primary goal in this study is to describe how preoperative cardiovascular risk can have an impact on weight loss and describe the impact of bariatric surgery on high cardiovascular risk patients.

Methods

After institutional review board (IRB) approval, we retrospectively reviewed our prospectively collected electronic database of all patients who underwent a bariatric procedure from December 2010 to December 2016 at our institution. This is a single-institution retrospective analysis. We included all patients that underwent bariatric surgery between the aforementioned years such as laparoscopic adjustable gastric banding, Roux-en-Y gastric bypass, laparoscopic sleeve gastrectomy, and revision procedures, and who met the criteria for calculating the Framingham risk score (FRS) and/or the atherosclerotic cardiovascular disease (ASCVD) score. These subjects were patients with no history of a cardiovascular disease such as coronary death, myocardial infarction, coronary insufficiency, angina, ischemic stroke, hemorrhagic stroke, transient ischemic attack, peripheral artery disease, and heart failure. Patients were on average 30–74 years old. All other patients were excluded from this study.

The aforementioned calculator provides a 10-year risk prediction of incidence of cardiovascular disease.

The FRS was obtained by creating an Excel spreadsheet calculator with the variables provided and based on the Framingham Heart Study [15]. The ASCVD score, created to assess the need to introduce statins in high cardiovascular risk patients to decrease the overall risk, was calculated with the variables provided and endorsed by the American Heart Association and the American College of Cardiologists [16].

The data that were required to analyze the risk scores included common demographics (age and gender), height, weight, high-density lipoprotein (HDL) cholesterol categories, triglycerides, blood pressure categories, diagnosis of diabetes, and treatment for essential hypertension. The risk was measured preoperatively and at 12 months of follow-up. The ideal risk was calculated using patients' mean age and was defined as BMI < 25 kg/m^2, cholesterol and lipid within normal ranges, no family history of diabetes, no usage of tobacco, and no treatment for hypertension. Furthermore, the percentage of BMI loss (%EBMIL) and total weight loss (%TWL) were calculated at 12 months of follow-up.

Data analysis

The data were collected from patient chart review and imported into JMP software (SAS Institute Inc, NC, US), which was then used to apply variable formatting and to change variable names to conform to the conventions needed for R (software R, version 3.3.1 (2016-06-21), R Foundation for Statistical Computing, Vienna, Austria). Data were described using mean and standard deviation for continuous variables, and counts and percentages for categorical variables.

Outcomes of clinical characteristics and postoperative results were described using the Chi-square, Fisher exact, and t tests. Sample sizes for individual variables reflect missing data. All analyses were performed on a complete-case basis. Linear regression and multiple linear regression were performed in order to analyze the impact of the preoperative risk scores on the %EBMIL. All tests were two-tailed and performed at a significant level of 0.05. Statistical software R, version 3.3.1 (2016-06-21) was used for all analyses.

Results

A total of 1330 charts were reviewed, of which 557 (41.72%) patients had a follow-up at 12 months. From these patients, only 360 (27.06%) patients had complete data to calculate the risk scores and met the aforementioned criteria for inclusions. Our population was predominantly female (70.27%, $N = 253$) Caucasians (67.5%, $N = 243$) with a mean age of 50.93 ± 11.87 years for females and 54.89 ± 10.9 years for males. Laparoscopic sleeve gastrectomy (LSG) was the most performed surgery (63.33%, $N = 228$) following by laparoscopic Roux-en-Y gastric bypass (LRYGB) (20.83%, $N = 75$). Diagnosis of Type 2 diabetes mellitus (T2DM) was present in 43.05% ($N = 155$) of our population, while treatment for hypertension and active tobacco use was present in 52.22% ($N = 188$) and 23.88% ($N = 86$), respectively. The average preoperative BMI was 43.32 ± 7.08. At 12 months of follow-up, the mean BMI was significantly reduced 10.79 kg/m^2 in females and 11.12 kg/m^2 in males. Furthermore, total cholesterol was reduced by 10 g/dL in females ($P = 0.0009$) and 5.9 g/dL in males ($P = 0.1782$). High-density lipoprotein levels significantly increase in both genders, and triglycerides significantly decreased. Table 1 further explains our findings when measured at 12 months of follow-up. Overall males had a significantly greater cardiovascular risk. The complete resolution of T2DM was

Table 1 Demographics and comorbidities before surgery and at 12 months of follow-up

	Preoperative	12 months	*P* value
Age (years)			
F	50.93 ± 11.87		
M	54.89 ± 10.9		
BMI (kg/m^2)			
F	42.71 ± 7.85	31.92 ± 6.37	< 0.0001
M	42.72 ± 7.42	31.60 ± 5.72	< 0.0001
Total cholesterol (mg/dL)			
F	193 ± 45.8	183 ± 38.47	0.0009
M	174.40 ± 36.19	168.5 ± 38.2	0.1782
HDL (mg/dL)			
F	54.83 ± 18.42	60.18 ± 16.55	< 0.0001
M	43.80 ± 10.72	54.37 ± 15.07	< 0.0001
Triglycerides (mg/dL)			
F	145.86 ± 95.2	105.76 ± 65.3	< 0.0001
M	165.55 ± 79.8	95.91 ± 47.5	< 0.0001
LDL (mg/dL)			
F	110.64 ± 35	101.85 ± 28.27	0.0006
M	98.24 ± 35.05	92.62 ± 343.49	0.1694
SBP (mmHg)			
F	129.40 ± 14.89	123.00 ± 15.81	< 0.0001
M	136.93 ± 18.0	127.57 ± 14.4	< 0.0001
Treatment HTN			
F	56.52% (*N* = 143)	34.78% (*N* = 88)	< 0.0001
M	59.81% (*N* = 64)	39.25% (*N* = 42)	0.0002
Diagnosis of T2DM			
F	40.71% (*N* = 103)	20.94% (*N* = 53)	0.0005
M	48.59% (*N* = 52)	25.23% (*N* = 27)	0.0003
Tobacco use			
F	22.13% (*N* = 56)	6.71% (*N* = 17)	< 0.0001
M	28.03% (*N* = 30)	12.14% (*N* = 13)	0.0037

Mean ± Standard deviation. % percentage (*N* number)

Significance at $P < 0.05$ was determined using Student's t test for continuous variables and Chi square for categorical variables

F female/*M* male, *HDL* high-density lipoprotein, *LDL* low-density lipoprotein, *HTN* essential arterial hypertension, *T2DM* type 2 diabetes mellitus

Table 2 ASCVD and FRS score reduction by gender

	Preoperative	12 months	Absolute risk reduction (%)	*P* value*
ASCVD 10 year risk (%)				
Female	7.97 ± 8.8	5.15 ± 6.6		< 0.0001
Male	17.11 ± 13.3	11.52 ± 11.49		< 0.0001
ASCVD lifetime risk (%)				
Female	40.61 ± 8.9	33.22 ± 12.97		< 0.0001
Male	57.18 ± 14.3	41.38 ± 20.0		< 0.0001
FRS 10 year risk (%)				
Female	15.71 ± 14.52	10.65 ± 10.9		< 0.0001
Male	33.13 ± 21.1	24.58 ± 17.6		< 0.0001
Heart/vascular age (years)				
Female	68.48 ± 15.54	60.94 ± 17.5		< 0.0001
Male	72.02 ± 14.68	64.61 ± 18.2		0.0005

Mean ± standard deviation

ASCVD atherosclerotic cardiovascular disease, *FRS* Framingham risk score

*Paired *T* test

achieved in 37% of patients, treatment for hypertension was reduced by 48.3%, and tobacco cessation was achieved by 65.1% of patients.

Preoperatively, males had an ASCVD score of 17.11 ± 13.3 versus 7.97 ± 8.8 for females. The FRS was also higher in males than in females (33.13 ± 21 vs. 15.71 ± 14.52, respectively). At 12 months of follow-up, both females and males had a significant reduction of their respective FRS and ASCVD risk scores. Table 2 better categorizes these findings. When categorized by severity of FRS, we found that 35.8% (*N* = 129) of our population had a low cardiovascular risk score (FRS < 10%), 29.4% (*N* = 106) had a moderate score (FRS 10–20%), and 34.72% had a high-risk score (FRS > 20%).

Regarding the type of procedure (Tables 3, 4), all but LAGB had a significant decrease in the FRS and ASCVD risk scores.

Furthermore, results from simple linear regression comparing preoperative cardiovascular risk scores and 12-month %EBMIL demonstrated a −0.3189 coefficient estimate for FRS (< 0.001) and −0.4283 ($P = 0.0083$) for ASCVD risk score, meaning that for every 1 unit increase on the preoperative FRS, the %EBMIL will reduce 0.31 units, and for every 1 unit increase on the ASCVD score, the %EBMIL will decrease 0.42 units. Finally, patients with a higher risk score tend to have less weight loss, with low-risk patients having a 4.79%EBMIL higher than the high-risk group.

Discussion

Bariatric surgery has dramatically changed the way we treat severe obesity. Every year, an increasing amount of severely obese patients undergo weight loss surgery [17]. Among all bariatric interventions, LSG has become the most frequently performed bariatric surgical approach in the US [18]. This tendency is also reflected in our patient population, with 63.3% of all procedures comprising LSG. Females composed more than 2/3 of our patient population; this trend is also reflected in every major bariatric publication [19]. The metabolic changes induced by a weight loss intervention are broad, and several authors have described these findings [14]. Lipids are one of the main variables used to

Table 3 Framingham risk score severity classification and the effect on the %EBMIL

FRS	Preoperative	12-month follow-up	*P* value*	%EBMIL
Low risk (*N* = 129, 35.9%)	5.82 ± 2.32	5.84 ± 5.48	0.9179	69.99
Moderate risk (*N* = 106, 29.4%)	14.81 ± 2.80	11.56 ± 8.75	0.0024	68.03
High risk (*N* = 125, 34.7%)	40.13 ± 17.05	25.85 ± 16.73	< 0.0001	65.20

Low risk (< 10%), moderate risk (10–20%), high risk (> 20%). All risks calculated using FRS

FRS Framingham risk score, *%EBMIL* percentage of estimated BMI loss

*Paired *T* test

Table 4 Type of surgery, ASCVD and FRS 10-year risk

Type of surgery	Preoperative	12-month risk	Absolute risk reduction	*P* value
LAGB (*N* = 6)				
ASCVD	12.13 ± 12.46	9.81 ± 13.044	2.32	0.75
FRS	25.68 ± 17.2	22.7 ± 17.49	2.98	0.1135
LSG (*N* = 159)				
ASCVD	10.33 ± 107	6.48 ± 8.0	3.85	< 0.0001
FRS	19.08 ± 17.4	13.08 ± 12.3	6	< 0.0001
LRYGB (*N* = 60)				
ASCVD	11.77 ± 11.58	8.31 ± 10.77	3.46	< 0.0001
FRS	26.37 ± 21.22	17.39 ± 19.05	7.98	< 0.0001
REVISION (*N* = 20)				
ASCVD	21.37 ± 14.08	18.15 ± 8.71	3.22	0.056
FRS	19.79 ± 20.00	16.06 ± 15.28	3.73	0.035

Mean ± standard deviation. *N* number. Paired *T* test

LAGB laparoscopic adjustable gastric banding, *LSG* laparoscopic sleeve gastrectomy, *LRYGB* laparoscopic Roux-en-Y gastric bypass, *ASCVD* atherosclerotic cardiovascular disease risk, *FRS* Framingham risk score

measure cardiovascular disease. The American Society for Bariatric and Metabolic Surgery (ASMBS) published a two-part scientific statement regarding this topic [5, 20]; in our study, except for low-density lipoprotein (LDL) in men, the values significantly changed at 1 year of follow-up. Similarly, triglycerides decreased while HDL levels significantly increased.

Schiavon et al. [21] published a randomized, single-center, nonblinded trial regarding blood pressure changes after bariatric surgery; in their study, they had a 83.7% reduction of the use of hypertensive medication and 51% remission of hypertension. Our study reflects similar values, with 48.3% of our patients having hypertension resolution—stressing the importance of weight management on arterial hypertension.

More than two-thirds of patients in this study had a moderate to high FRS at baseline. High FRS (> 20%) as per the World Health Organization [22] was found in 34% of our patient population. The significance of this score is that if there were no reductions in the CV risks due to weight loss surgery or other interventions, at least 20 out of 100 patients would develop a fatal or nonfatal cardiovascular event in the next 10 years. These patients benefit the most from a bariatric intervention, with a significant risk reduction at 12 months of follow-up, correlating with the literature and our previously published data regarding this topic in which females and males had a 36.9% and 25.6% relative risk reduction after 12 months of follow-up, respectively [10, 23].

The ASCVD risk score was also calculated in our patient population. As mentioned, this is a fairly new tool to measure cardiovascular disease published by the American Heart Association and the American College of Cardiology in 2013 [16]. The ASCVD score was also high in our patient population and dramatically decreased at 12 months of follow-up. This is to our knowledge one of the first studies to describe the effect of a weight loss intervention, especially after LSG, on the ASCVD score, with most published studies using the Framingham Risk Score in RYGB patients. All but adjustable gastric banding patients (probably due to the small population) benefit from a bariatric surgery from a cardiovascular standpoint. However, revisions are complex, involving multiple types of procedures, including mostly conversions, which could potentially bias the specific results for this population.

Weight loss and weight regain after bariatric surgery is a topic of discussion in the bariatric literature. Several factors, some of them not yet identified, influence the overall weight loss pattern of severely obese subjects that undergo bariatric interventions [24, 25]. Although it is difficult to define an ideal weight loss after bariatric surgery, most authors agree that the ideal weight loss is defined as an EBMIL greater than 50% [26]. On average, our patient population had an EBMIL of 67%, similar to most major publications [22]. Results from linear and multiple linear regression analysis demonstrated the impact of preoperative cardiovascular risk on the estimated BMI loss at 12 months of follow-up, noticing that weight loss patterns are complex and multiple preoperative values can be correlated with decreased weight loss (Table 5) [27]. When divided by severity of the FRS, we found that patients with a high FRS have around 5% less EBMIL than low-risk patients. This observation can be explained by the fact that these patients are sicker, have more

Table 5 Simple and multiple linear regression comparing preoperative risk and 12-month %EBMIL

	Coefficient estimate	*P* value
Simple linear regression		
Pre-op Framingham risk score	−0.3189	< 0.001
Pre-op ASCVD risk 10 year	−0.4283	0.0083
Multiple linear regression results		
Pre-op Framingham risk score	−0.474	0.0377
Pre-op ASCVD risk 10 year	0.322	0.4377

ASCVD atherosclerotic cardiovascular disease risk, *Significance* < 0.05, *pre-op* preoperative, *post-op* postoperative

comorbidities, and are slightly older—affecting the ability to effectively lose weight as other authors have described [28, 29]. However, although these patients lose less weight, they benefit the most from a bariatric intervention, especially from a cardiovascular risk standpoint. On average, our high FRS patients had an absolute risk reduction of 14.38% (RRR 35.8%) versus an absolute FRS increase of 0.02% in our low-risk population, probably due to normal aging.

Study limitations

One of our major limitations is related to the retrospective nature of our study. In addition, although 100% of our patients had the required variables in the preoperative settings, only 27% of our population had the required variables to calculate the risk at 12-month follow-up, limiting our results to this specific population and thus increasing the chances of bias and significantly reducing our population. Loss to follow-up was almost 60% in our study. The latter limits our conclusions since we do not know the long-term outcomes. Furthermore, although all measured variables comprising cardiovascular risk were reduced at 12 months of follow-up, not all of them were directly attributable to surgical weight loss, such as cessation of tobacco use. Finally, the FRS and ASCVD calculators assess the presence or not of a specific disease such as diabetes, not accurately measuring the risk on patients who had a significantly reduced use of medications or better glucose control but are still considered diabetic.

Further studies are needed to better assess long-term results of these findings.

Conclusion

Patients with a high Framingham risk score lose less weight than those with a low Framingham risk score; however, high cardiovascular risk patients benefit the most after a weight loss intervention. Our results suggest that the atherosclerotic cardiovascular disease and Framingham risk score are equally reduced after bariatric surgery, especially after LSG and LRYGB. Moreover, the preoperative Framingham risk score and ASCVD risk score showed an inversely proportional relationship with %EBMIL loss at 12 months. One of the main weaknesses of this study is the limited sample size, which decreases the strength of our conclusions. Further studies are needed to better understand these findings in the longer term.

Compliance with ethical standards

Disclosures David Gutierrez Blanco, David Romero Funes, Giulio Giambartolomei, Emanuele Lo Menzo Samuel Szomstein, and Raul J. Rosenthal have no conflicts of interest or financial ties to disclose.

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