Cardiovascular risk reduction following metabolic and bariatric surgery

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Abstract: Cardiovascular disease (CVD) is the world's leading cause of mortality and obesity is a well-recognized risk factor of CVD. Early detection and management of CVD is critical to reduce CVD risk. Especially in patients suffering from obesity with obesity-related CVD risk factors such as hypertension (HTN), dyslipidemia, and diabetes mellitus (DM). A substantial and sustained decrease in body weight after metabolic and bariatric surgery is associated with a significant reduction of cardiovascular risk factors. This article reviews CVD risk models, mechanisms of CVD risk associated with obesity, and overall CVD risk reduction between different metabolic and bariatric procedures.

Keywords: Cardiovascular risks; metabolic and bariatric surgery; risk reduction; cardiovascular risk reduction

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Introduction

Cardiovascular disease (CVD) is the world's leading cause of mortality, representing approximately 31% of all deaths, or approximately 18 million people annually. Obesity has been well established as a major risk factor of CVD. The World Health Organization (WHO) emphasizes the need for early detection and management of CVD in patients suffering from obesity and other medical risk factors such as hypertension (HTN), dyslipidemia, and diabetes mellitus (DM). Addressing behavioral risk factors such as tobacco use, unhealthy diet, physical inactivity, and harmful use of alcohol can also result in profound improvements in CVD (1).

Modest weight loss in patients suffering from obesity produces improvement in type 2 diabetes mellitus (T2D), HTN and dyslipidemia [hypertriglyceridemia, insufficient high-density lipoprotein (HDL) cholesterol, and excessive low-density lipoprotein (LDL)] cholesterol; however, nonsurgical weight loss trials have failed to demonstrate any benefit in terms of CVD events in individuals suffering from obesity (2-5).

Alternatively, metabolic and bariatric procedures demonstrate significant CVD risk reduction and mortality reduction, while often completely eliminating numerous comorbidities and improving quality of life (6). The aim of this publication is to review CVD risk models, CVD risk associated with obesity, and overall CVD risk reduction between different metabolic and bariatric procedures.

Risk factors for CVD and models used for calculating CVD risk

Population-based CVD risk models focusing on traditional risk factors have been developed into guidelines aimed to improve cardiovascular (CV) health. *Table 1* shows the different risk assessment tools being used worldwide, with risk factors measured to determine CVD risk (7-13).

The Framingham study identified age (males ≥45 years or females ≥55 years), gender (male sex), HTN, dyslipidemia, smoking, and DM as risk factors for developing coronary heart disease (CHD). The initial Framingham Risk Score (FRS) was developed in 1998 as a means to assess CHD

Table 1 Risk prediction models used to calculate CVD risk

Risk model	Risk assessment	Risk factors
ACC/AHA ASCVD Pooled Cohort Risk Calculator	10-year and lifetime risk of CV event: CHD mortality, MI, fatal stroke, nonfatal stroke	Age, sex, race, TC, HDL-C, SBP, DBP, DM status, smoking status, hypertension treatment
Framingham Risk Score	10-year risk of CHD	Age, sex, LDL-C, HDL-C, SBP, DBP, DM status, smoking status, hypertension treatment
European Systematic Coronary Risk Evaluation algorithm (SCORE)	10-year risk of fatal CVD event	Age, sex, TC, SBP, smoking status
QRISK® 3-2018 Calculator	10-year risk of MI or stroke	Age, sex, ethnicity, C/HDL-C ratio, smoking status, angina in 1st degree relative, CKD (stage 3/4/5), hypertension treatment, RA, SLE, mental illness, steroid treatment, erectile dysfunction, BMI
Prospective Cardiovascular Münster (PROCAM) Model	10-year risk of acute MI or sudden coronary death	Age, LDL-C, HDL-C, TG, SBP, smoking status, SM, status, family history of premature MI
Reynolds Risk Score (RRS)	10-year risk of MI, stroke, angioplasty or CVD mortality	Age, sex, SBP, TC, HDL-C, family history of premature MI, hsCRP
United Kingdom Prospective Diabetes Study (UKPDS)	10-year risk of nonfatal, and fatal, stroke and CHD	Age, sex, ethnicity, SBP, DM status, smoking status, TC, HDL, A1C, atrial fibrillation
Registre Gironí del Cor (REGICOR)	10-year risk of MI, mortality	Age, sex, SBP, DBP, TC, HDL-C, DM status, smoking status

ACC/AHA/ASCVD, American College of Cardiology/American Heart Association/Atherosclerotic Cardiovascular Disease; CV, cardiovascular; TC, total cholesterol; HDL-C, high density lipoprotein-cholesterol; LDL-C, low density lipoprotein cholesterol; SBP, systolic blood pressure; DBP, diastolic blood pressure; DM, diabetes mellitus; C, cholesterol; CKD, chronic kidney disease; RA, rheumatoid arthritis; SLE, systemic lupus erythematosus; BMI, body mass index; TG, triglyceride; MI, myocardial infarction; hsCRP, high sensitivity C-reactive protein; CHD, coronary heart disease; CVD, cardiovascular disease.

risk and was refined by the ATP-III in 2002 with a focus on CHD endpoints, mortality, and nonfatal myocardial infarction. The 2008 Framingham General CVD Risk Score incorporated additional CV endpoints including stroke, heart failure, and peripheral arterial disease (14-16).

The 2013 ACC/AHA (American College of Cardiology/American Heart Association) Pooled Cohort Atherosclerosis Cardiovascular Disease (ASCVD) Risk Score is now widely used and is derived from several studies: the Framingham original and offspring cohorts, the Atherosclerosis Risk in Communities (ARIC) study, the Coronary Artery Risk Development in Young Adults (CARDIA) study, and the Cardiovascular Health Study (CHS) (17-20).

Other multivariate risk models have been developed and incorporate different variables including HbA1C levels, atrial fibrillation, chronic kidney disease, erectile dysfunction in males, and systemic inflammation such as rheumatoid arthritis or systemic lupus. Family history of premature atherosclerotic CVD (age <55 years for males and <65 years for females) has also been included in some of the risk assessment models. Of note, limitations exist with all CVD risk models, as some individuals who develop CVD may have few, if any, known risk factors (21). Also challenging is the fact that more than one-third of individuals with HTN in the United States are undiagnosed, and only 30–40% of patients with elevated low-density lipoprotein cholesterol (LDL-C) are prescribed lipid-lowering therapies (14,21). Understanding these limitations can aid in patient counselling.

Concepts of CVD risk reduction

There are modifiable and non-modifiable risk factors associated with CVD. Modifiable risk factors include a sedentary lifestyle, tobacco use, unhealthful diet, obesity, HTN, T2D, and dyslipidemia. Traditionally, health care providers have focused on lifestyle interventions and medications to reduce CVD risk. Recently however, a concept has emerged of using surgical alterations of the gastrointestinal tract to reduce CVD risk. This category of surgery is referred to as metabolic surgery because of the myriad of metabolic benefits that have been demonstrated to occur. This type of surgery is also known as bariatric surgery because the primary goal has historically been weight loss. The current era of surgery for weight loss has proven to be a safe, effective and durable for patients with class 2 and 3 obesity. However, support for current procedures may be inappropriately withheld due to bias against historical procedures often linked to significant morbidity and mortality. For example, patients undergoing jejunoileal bypass were subjected to developing significant nutritional complications and cirrhosis. Additionally, undesirable morbidity and mortality was seen prior to and early in the laparoscopic era of bariatric surgery. Bariatric surgery has since evolved from being a procedure primarily designed for weight loss to now being the best available treatment option for improving the metabolic burden of obesity. Most obesity-related comorbidities significantly improve or completely resolve after surgery, particularly factors associated with CVD risk, such as diabetes and insulin resistance, hemodynamic and inflammatory parameters, dyslipidemia, and adiposity with its associated pathophysiology (22).

One of the most common directives that patients are given to reduce CVD risk is to increase physical activity. Studies show that performing more than 150 minutes of moderate physical activity, or 75 minutes of vigorous physical activity, every week can achieve a 30% CVD risk reduction, and walking at least two hours a week reduced the incidence of premature death from CVD by about 50% (23,24). However, patients with severe obesity often suffer from physical limitations due to severe joint and back pain, which can ultimately lead to a sedentary lifestyle; thus, generating a vicious cycle of inactivity, low exercise capacity, further weight gain, and ultimately, increased mortality risk. By halting and then reversing the vicious cycle of obesity and impaired exercise tolerance, weight loss after bariatric surgery leads to increased physical activity levels. Reduction of body weight after LRYGB surgery is associated with significantly improved cardiorespiratory function 6 months after surgery, especially in patients who lost more than 18% of their initial body weight (25). A meta-analysis of 26 studies looked at changes after bariatric surgery in self-reported physical activity and objectively measured cardiovascular endurance (26). All but one study reported an increase in self-reported physical activity 12 months after surgery. Patients were physically active for a greater period of time, but at a lower intensity in the first 6 months following surgery; this was demonstrated by a reduction in moderate to vigorous activity but an increase in daily step count on average of 1,225–2,749 more steps per day. All studies assessing endurance testing, either by treadmill or timed walking tests, reported improvements after bariatric surgery.

Another highly frequent goal in the effort to reduce CVD risk is weight loss. In particular, waist circumference, especially when due to excess visceral fat, is more strongly correlated to the development of metabolic syndrome and, ultimately, adverse CV outcomes than body mass index (BMI) (27-29). Excess visceral adiposity has been linked to many CVD risk factors including dyslipidemia, insulin resistance, hyperinsulinemia, glucose intolerance, altered fibrinolysis and endothelial dysfunction. Even at a healthy BMI, excess visceral adiposity is associated with a harmful increased accumulation of ectopic fat in the heart, liver, and skeletal muscle, which might contribute to increased atherosclerosis and CVD risk (30). Visceral fat has a strong effect on CVD risk, partially since it impairs immune function and alters leukocyte counts and cell-mediated immune responses (31). Visceral adipocyte enlargement also triggers endoplasmic reticulum stress and hypoxia, which stimulates the expression of inflammatory genes and activates immune cells. In addition, increased leptin (pro-inflammatory mediator) and the reduction in adiponectin (anti-inflammatory mediator) activate immune cells. Bariatric surgery has been shown to reduce visceral fat with subsequent improvement of leukocytosis, inflammation and endothelial dysfunction. A systematic review demonstrated a significant reduction in C-reactive protein (CRP), interleukin-6, tumor necrosis factor-α (TNF-α) levels after bariatric surgery (32). LRYGB has been shown to markedly improve inflammatory markers (interleukin-6 and C-reactive protein) and endothelial function (Intracellular adhesion molecule-1, tissue-type plasminogen activator antigen and von Willebrand factor). These improvements were sustained 24 months post-surgery (33). LRYGB and laparoscopic sleeve gastrectomy (LVSG) significantly lowered high sensitivity-CRP levels for patients with elevated CVD risk (34). Erythrocyte sedimentation rate, which is a known predictor of coronary heart disease, is also improved post-surgery (35,36).

CVD risk improvement after bariatric surgery

Currently, LVSG is the most common metabolic and bariatric surgery procedure performed, 46% of all procedures, in the world. In the United States, LVSG represents 60% of all bariatric procedures (37,38). However, in a 2011 systematic review of 52 studies looking at CVD risk, most of the patients underwent open and LRYGB (45.8%) with only 0.2% undergoing LVSG. The review demonstrated a 40% relative risk reduction of CVD and striking remission rates, or improvement, for HTN, T2D and dyslipidemia (68%, 75% and 71% respectively) (39). Current data analyzing CVD risk and bariatric surgery since this review have demonstrated similar results in single institution studies. While there is a lack of CVD-specific randomized control trials, several randomized controlled studies looking primarily at patients receiving medical versus surgical treatment for T2D demonstrated a significant improvement in CVD risk (40,41).

An observational study by Adams and colleagues looked at HTN, T2D and dyslipidemia in LRYGB patients with 12-year follow-up, compared to nonsurgical patients who sought to have surgery but did not primarily for insurance reasons, and a third group of nonsurgical patients who did seek to undergo surgery. This study showed long-term durability of weight loss and effective remission and prevention of T2D, HTN, and dyslipidemia after LRYGB. Each one of the CVD risk factors was significantly better in the surgery group compared to the non-surgery control groups. In particular, T2D, low levels of HDL-C, and high triglyceride levels were each nearly eliminated from the LRYGB group (42).

Another randomized study further demonstrated the superiority of surgical over medical therapy in CVD risk reduction in obese patients with T2D. Three years after randomization between bariatric surgery and intensive medical weight management, surgical patients had greater weight loss, lower HbA1C, reduced cardiovascular risk, and improved obesity-related quality of life (43). In a study with longer follow-up, a longitudinal cohort of 1,048 patients undergoing LRYGB demonstrated a significantly lower CV risk from the first year after surgery that was sustained to the fifth postoperative year. After 5 years, the amelioration of the lipid profile itself yielded to a 27% reduction of CV risk (P<0.001) (44).

In another randomized control trial, patients with class II or III obesity and T2D for at least 5 years were randomly assigned to LRYGB, BPD or medical treatment. The primary endpoint was the rate of diabetes remission at 2 years, but evaluating cardiovascular risks was one of the secondary endpoints. Both surgical procedures were associated with significantly lower plasma lipids, cardiovascular risk, and medication use. Five major complications of diabetes (including one fatal myocardial infarction) arose in four (27%) patients in the medical group compared with only one complication in the gastric bypass group and no complications in the BPD group. Although the BPD group appeared to have lower CVD risk compared to LRYGB, the statistical analysis was focused on comparison of the surgical *vs.* nonsurgical groups, and there was no statistical analysis to determine if there was a significant difference between the two surgical procedures (41).

The single anastomosis duodeno-ileal bypass with laparoscopic vertical sleeve gastrectomy (SADI-S) has been shown to have even better CVD risk reduction compared to LRYGB. Torres *et al.* reviewed data from 149 patients undergoing LRYGB compared to 106 patients undergoing SADI-S. Mid-term follow-up of 3 years demonstrates better weight loss and improvement of blood pressure, lipid profile, and insulin resistance with SADI-S than with LRYGB. Long-term follow up is needed to determine if this difference remains significant (45).

Prachand *et al.* reported that DS provides superior resolution of T2D, HTN, dyslipidemia compared to LRYGB. Prospectively collected data in 350 patients (198 and 152 patients underwent DS and LRYGB, respectively) revealed that diabetes, HTN, and dyslipidemia resolution was significantly greater at 3 years for DS compared to LRYGB (diabetes, 100% *vs.* 60%; HTN, 68.0% *vs.* 38.6%; dyslipidemia, 72% *vs.* 26.3 (46).

Alexandrides *et al.* also reported that patients undergoing a variant of BPD, BPD-LRYGB, experienced superior improvement of T2D, TC and TG and blood pressure compared to LRYGB patients. T2D resolved in 89% and 99% of the cases following LRYGBP and BPD-LRYGBP, respectively. Both procedures lead to normalization of blood glucose, lipids, uric acid, liver enzymes and arterial pressure in the majority of patients, but this variant of BPD was more effective than LRYGB. Two years after BPD-LRYGBP, 100% patients had blood glucose <110 mg/dL, 95% had normal cholesterol, 92% normal triglycerides and 82% normal blood pressure. Patients undergoing LRYGBP with normal values were 66%, 33%, 78% and 44%, respectively (47).

Other cardiovascular benefits after bariatric surgery

Atherosclerosis has been linked to circulating inflammation, and reduction in this circulating inflammation may explain

Table 2 Relative CVD risk reduction determined in studies using risk prediction models

Author	Year	Risk prediction model used	Procedure breakdown [n]	10-year CVD relative risk reduction
Blanco *et al.* (54)	2019	FRS; ACC/AHA ASCVD	LRYGB [60]; LVSG [159]	32.8%, 42.1%; 27.6%, 38.7%
Raygor *et al.* (56)	2019	ACC/AHA ASCVD	LRYGB [438]; LVSG [98]	54%; 30%
Wei *et al.* (57)	2018	UKPDS Risk Score	LRYGB [305]; LVSG [87]; SAGB [204]	33%; 50.5%; 52.4%
Gutierrez-Blanco *et al.* (62)	2018	FRS	LRYGB [779]; LVSG [220]	36.3%; 38.1%
Benotti *et al.* (61)	2017	FRS	LRYGB [1,724]	42%
Piché *et al.* (63)	2014	FRS	BPD-DS [22 female]; BPD-DS [51 male]	43%; 33%
Largent *et al.* (64)	2013	FRS	LAGB [697]	29.6%
Benaiges *et al.* (55)	2011	FRS; REGICOR	LRYGB [95]; LVSG [45]	52.1%, 39.2%; 51.2%, 40.6%
Arterburn *et al.* (60)	2009	FRS	LRYGB [92]	19.4%
Batsis *et al.* (59)	2008	FRS; PROCAM	LRYGB [197]	50%; 51.2%
Torquati *et al.* (58)	2007	FRS	LRYGB [500]	50%

FRS, Framingham Risk Score; ACC/AHA/ASCVD, American Colle of Cardiology/American Heart Association/Atherosclerotic Cardiovascular Disease; REGICOR, Registre Gironí del Cor; UKPDS, United Kingdom Prospective Diabetes Study; PROCAM, Prospective Cardiovascular Münster Model; LRYGB, Roux-en-Y gastric bypass; LVSG, sleeve gastrectomy; SAGB, single anastomosis gastric bypass; LAGB, laparoscopic adjustable gastric banding; BPD-DS, biliopancreatic diversion-duodenal switch.

improvements in the clinical indicators of CVD. Coronary calcification was shown to be significantly improved with sustained weight loss six years after LRYGB (48). Patients with obesity tend to have significantly increased carotid intima-media thickness (IMT) and impaired flow-mediated dilation (FMD). After surgery, a significant reduction of IMT and a significant improvement in FMD. Percent changes in BMI were associated with changes in IMT and FMD (49).

Metabolic and bariatric surgery has also been shown to decrease left ventricle (LV) mass and relative wall thickness, improve LV diastolic function, and decrease left atrium diameter. These changes were seen within six months after surgery. Measurement of right ventricle (RV) size and function, RV end-diastolic area and estimated RV systolic pressure are noted to improve significantly after LRYGB (50-53).

Bariatric surgery improves CVD risk scores

Several studies have more conclusively proven that bariatric surgery reduces CVD risk by demonstrating improved scores in accepted CVD risk models (54-64) (*Table 2*). Blanco *et al.* performed a retrospective review of the records of metabolic and bariatric surgery patients who met the criteria for calculating the 10-year ACC/AHA ASCVD risk score 10-year and the FRS. They demonstrated that both LVSG and LRYGB are equally effective in significantly reducing cardiovascular risk, with no statistical differences between the two procedures. Propensity score matching was used to match LVSG and LRYGB on demographic characteristics and co-morbidities. LVSG was performed in 159 patients compared with 60 patients undergoing LRYGB. At 12-month follow-up, the ASCVD 10-year score showed an absolute risk reduction of 3.9%±6.5% in LVSG patients and 2.9%±5.8% in LRYGB patients (P=0.3), resulting in a relative CVD risk reduction of 39% and 27.6%, respectively. The FRS calculated an absolute risk reduction of 10.7% in LVSG patients and a 9.1% in LRYGB patients, resulting in a relative CVD risk reduction of 42.1% and 32.8%, respectively. Significant decreases in the estimated heart age of 12.1±15.6 years was seen in LVSG versus 9.2±9.6 years in LRYGB (P=0.1) (54).

In a prospective cohort study of 140 consecutive patients (95 LRYGB and 45 LVSG) compared the 2 surgical intervention groups to study the percentage of excess weight loss, resolution and improvement/resolution of co-morbidities, and effect on CVD risk using both the FRS and the Registre Gironí del Cor (REGICOR) risk models. At one year, the overall CV risk decreased from 6.6% to 3.4% using the FRS and from 3.7% to 1.9% using the REGICOR score. No statistical differences were noted between the two surgical intervention groups. At 12 months, FRS decreased 3.4%±2.2% for LRYGB versus 3.3%±2.1% for LVSG (P=0.872), and the REGICOR score decreased 1.9%±1.5% versus 1.8%±1.6%, respectively (P=0.813). The improvement, or resolution, of hypercholesterolemia was higher in the LRYGB group compared to the LVSG group (55).

Using the ACC/AHA ASCVD Pooled Cohort Risk Calculator, Raygor *et al.* looked at 10-year and lifetime ASCVD risks before and 1 year after metabolic and bariatric surgery for patients aged 40–78 who underwent LRYGB or LVSG. They demonstrated that patients who undergo LRYGB may experience greater cardiovascular risk reduction relative to counterparts who undergo LVSG. Of the 536 patients who underwent metabolic and bariatric surgery, 438 underwent LRYGB and 98 underwent LVSG. Significantly lower 10-year ASCVD risk for LRYGB and LVSG was 1.7%±3.5% *vs.* 0.8%±2.4% (P<0.001), and lifetime ASCVD risk was 11%±23% *vs.* 0%±12% (P<0.001), compared to baseline measurements. Relative risk reduction was 54% in LRYGB patients and 30% in LVSG patients. The authors concluded that patients who underwent LRYGB experienced greater reductions in 10-year and lifetime ASCVD risks from baseline to 1 year after surgery than patients who underwent LVSG. Greater risk reduction was seen in patients who were females, age <60 years, and with a BMI of 35–50 kg/m^2 (56).

In a single institution review from China, Wei *et al.* looked at cerebral and coronary heart disease risk calculated using The UK Prospective Diabetes Study risk engine. The CVD risk reduction seen was up to 50% and LRYGB appeared to have a greater effect on CVD risk reduction than LVSG one year after surgery. Outcomes were assessed in 392 patients (60% female) who had undergone LVSG (n=87) or LRYGB (n=305) for treatment of T2D with one-year follow-up. One year following surgery, the 10-year CHD risk were significantly reduced from 8.8% to 5.9% in LVSG patients, and from 10.1% to 5% in LRYGB patients, representing a 33% and 50.5% relative CVD risk reduction, respectively. Ten-year risks for fatal CHD events significantly decreased as well (38.1% *vs.* 55.4%, respectively). Similar CVD risk reduction was seen in patients with BMI ≥35 and BMI <35 one year after surgery. CVD risk was also calculated in 204 patients undergoing single anastomosis gastric bypass, demonstrating a 10-year CHD risk reduction of 52.4% and a 10-year fatal CHD event risk reduction of 59.5% (57).

Torquati *et al.* performed a single institution analysis of the change in CVD risk factors using the FRS to calculate the predicted 10-year absolute and relative risk of CHD in 500 patients undergoing LRYGB. The risk predicted by the FRS was then compared with the actual incidence of CHD events of the cohort. Compared with baseline, the average 10-year absolute risk of cardiac events decreased from 5.4% at baseline to 2.7% at 1 year after operation. A similar risk reduction was observed in subgroups defined by diabetes status and gender. LRYGB decreased absolute risk of cardiac events by a mean of 63% in patients with diabetes, and 56% in male patients. At 5 years, the actual incidence of CHD events was considerably lower than the predicted rate prior to LRYGB (58).

Batsis *et al.* performed a systematic review and calculated 10-year CVD risk using FRS and Prospective Cardiovascular Munster Heart Study (PROCAM) risk score. The analysis comprised a validation cohort of 197 patients who underwent LRYGB and 163 control patients. The surgery group realized a significantly reduced FRS (7.0% to 3.5%), a 50% risk reduction, compared with 8.5% risk reduction seen with nonsurgical control patients. PROCAM risk in the bariatric surgery group decreased from 4.1% to 2.0% (P<0.001), whereas the control group exhibited only a modest 13.6% risk reduction (59).

Arterburn *et al.* estimated cardiovascular risk using the FRS in 92 patients undergoing LRYGB. The predicted baseline 10-year CVD risk was 6.7%. At 6 and 12 months, the predicted risk had decreased to 5.2% and 5.4%, respectively with an absolute risk reduction of 1.3%, suggesting that 77 patients with class II or III obesity would have to undergo LRYGB to avert one new case of CVD over the ensuing 10 years (60).

Benotti *et al.* used the FRS to demonstrate LRYGB is associated with a reduced risk of myocardial infarction, stroke and the development of congestive heart failure (CHF). In a matched cohort study comparing 1,724 LRYGB patients and 1,724 nonsurgical patients followed for up to 12 years after surgery (median, 6.3 years), a statistically significant reduction in major composite cardiovascular events was seen in the LRYGB group, noting a 42% risk reduction of severe composite cardiovascular events. After LRYGB, significant improvement was seen in the 10-year CVD risk score, TC, HDL, SBP, and T2D. The control group only realized an approximately 14% reduction (61).

Gutierrez-Blanco *et al.* demonstrated that LVSG has a positive impact in the reduction of the 10-year CVD risk using the FRS in a retrospective review of all patients who underwent metabolic and bariatric surgery. The initial

Framingham 10-year score risk was significantly higher in males compared with females, and after 12-month follow-up, a significant absolute risk reduction was seen in males (11.58%; P<0.001) and 6.17% in females (P<0.001). The preoperative heart age was high in females and males [69.23±15.72 years and 73.55±13.55 years, respectively (P=0.012)], and after 12 months it reduced 7.19 years in females (P<0.001) and 7.04 years in males (P<0.001) (62).

The 10-year predicted risk for CHD was estimated using the FRS in 73 patients who underwent biliopancreatic diversion with duodenal switch (BPD-DS) and compared with 33 nonsurgical control patients. Predicted risks were stratified into 3 groups: (I) high short-term predicted risk (≥10% 10-year risk or diagnosed diabetes), (II) low short-term (<10% 10-year risk)/low lifetime predicted risk or (III) low short-term/high lifetime predicted risk. A significant reduction in HbA1C, Homeostatic Model Assessment of Insulin Resistance (HOMA-IR), all lipoprotein levels, and blood pressure was seen in the surgery group. The 10-year CHD predicted risk decreased by 43% in women and 33% in men, whereas the estimated CHD risk in the nonsurgical group did not change. Before surgery, none of the women and only 18% of men showed low short-term/low lifetime predicted risk, whereas a significant proportion of subjects had high short-term predicted risk (36% in women and 12% in men). Following surgery, 52% of women and 55% of men have a low short-term/low lifetime predicted risk (63).

Although LAGB accounts for approximately 7% of all bariatric procedures worldwide, and only 1% in the United States, studies have demonstrated significant long-term CVD risk reduction. Stable weight loss and significant improvement of cardiovascular risk profile were observed in patients with class I, II and III obesity after LAGB. The FRS was used to calculate estimated 10- and 30-year CVD risk reduction after LAGB in adult patients with obesity (BMI ≥30 kg/m²). Surgery patients were propensity matched with nonsurgical patients. Ten- and 30-year estimated CVD risk significantly decreased from 10.8% to 7.6% and 44.34% to 32.30% (P<0.0001), respectively, 12 to 15 months post-LAGB. In a cohort with lipid data (n=74), improvements in TC and HDL-C were also seen one-year post-LAGB (64).

Bariatric surgery reduces cardiovascular events

Several matched cohort studies reported the relationship between metabolic and bariatric surgery with major adverse cardiovascular events (MACE) in patients with T2D. Aminian *et al.* investigated adult patients with diabetes and obesity, matching one metabolic and bariatric surgery patient to five nonsurgical patients. 63% of the cohort underwent LRYGB and 32% underwent LVSG. Patients in the surgical group experienced a 39% reduction in first occurrence of all-cause mortality, coronary artery events, cerebrovascular events, heart failure, nephropathy, and atrial fibrillation. Additionally, when talking into account myocardial infraction, ischemic stroke and mortality as endpoints, patients in the surgical group realized a 41% risk reduction (65).

Fisher *et al.* looked at the incidence of coronary artery disease, cerebrovascular disease, and mortality in obese patients with type 2 diabetes undergoing metabolic and bariatric surgery compared to nonsurgical patients. The distribution of surgical patients included 76% LRYGB, 17% LVSG, and 7% LAGB. At 5 years, surgery was associated with a 40% risk reduction of macrovascular events and a 67% risk reduction in all-cause mortality (66). The reported 2 to 3 times lower annual event rates reported by Fisher, compared to Aminian, may due to a lower-risk cohort.

The Swedish Obese Subjects (SOS) study is one of the largest prospective, nonrandomized controlled studies looking at outcomes between matched cohorts receiving metabolic and bariatric surgery and nonsurgical care. The surgery patients had significantly fewer CVD deaths: 20 events among 2,010 patients in the surgery group (1.0%) versus 49 events among 2,037 patients in the control group (2.4%), resulting in a 53% risk reduction. Additionally, the surgery group had significantly fewer first time CVD events (myocardial infarction or stroke, whichever came first) with 33% risk reduction. The same group also reported obese patients with T2D that included 343 surgical and 260 control patients. Metabolic and bariatric surgery was associated with significantly fewer macrovascular events than patients receiving nonsurgical care. The distribution of cases, however, were 66% vertical banded gastroplasty, with LAGB and LRYGB representing 18% and 13.2% of the surgical cohort, respectively (67,68). Despite that, the study emphasizes the superior value of surgical, compared to nonoperative, management of obesity and its comorbidities.

In a study specific to patients receiving a LAGB, the 10-year probability of myocardial infarction was calculated using the PROCAM risk score and then compared to observed occurrences over time. A total of 318 patients (58 men and 260 women) underwent LAGB and follow-up was 12.7±1.5 years.

A significant reduction was observed in blood glucose, TC, triglycerides, and SBP and DBP pressure at short-term evaluations and confirmed after long term evaluations. HDL-C was unchanged at 12–18 months, but significantly increased at 12.7 years. Five coronary events (1.6%) were recorded during long-term follow-up, which was slightly lower than the expected rate (2.0%±4.9%) (69).

Conclusions

A substantial, and sustained, decrease in body weight after metabolic and bariatric surgery is associated with a significant reduction of cardiovascular risk factors such as T2D, HTN and hypertriglyceridemia. Several studies have demonstrated equally effective outcomes regardless of which procedure is performed, while others suggest that patients undergoing LRYGB, and even DS, experience a greater reduction in CVD risk. The comparison studies to date are insufficient to definitively conclude which procedure provides the best CVD risk reduction in the short, or long, term. However, DS appears to have better long-term reduction in CVD risk factors, followed by LRYGB, LVSG and LAGB. Randomized control trials are required to better define and confirm which procedure is indeed the most superior at reducing CVD risk.

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Footnote

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