

## Effects of Bariatric Surgery on Cardiovascular Outcomes in Obese Individuals: A Literature Review

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### ABSTRACT

Obesity remains a worldwide concern due to the plethora of adverse health effects affecting numerous organ systems and organ dysfunction. It is associated with substantial comorbidities, mortality, and morbidity. While conventional approaches to weight loss stress heavily on food and pharmacological choices, recent studies on the positive effects of bariatric surgery have significantly altered the management of obesity, with encouraging outcomes. Obesity is a major risk factor for cardiovascular disorders, diabetes mellitus, and hypertension; however, the effects of bariatric surgery in mitigating this risk are not fully understood. In this literature review, we intend to describe the current data on the effects of bariatric surgery on cardiovascular outcomes in obese individuals.

**Keywords:** Obesity; Bariatric surgery; Plethora

### INTRODUCTION

The prevalence of obesity in the US was estimated to be 42.4% in 2017-2018, which reportedly increased from 30.5% from 1999-2000 through 2017-2018 [1]. The estimated annual medical cost of obesity in the United States was \$147 billion in 2008 and was assessed to be \$1,429 higher for obese individuals than the medical

costs for people with healthy weight<sup>[1]</sup>. One of the most devastating consequences of obesity is the rising prevalence of cardiovascular disease (CVD), the leading cause of death in the US.

Weight reduction has been the cornerstone approach, whether via lifestyle adjustments, pharmacological treatments, or surgical procedures. However, the efficacy of lifestyle modifications and pharmaceuticals in improving CVD outcomes has been inconsistent<sup>[2]</sup>. There is compelling evidence that bariatric surgery is a more dependable way of weight loss than either pharmaceutical or lifestyle interventions<sup>[3]</sup>. Several studies of overweight and obese patients with CVD suggest an “obesity paradox,” whereby elevated body mass index (BMI) may be associated with lower mortality and cardiovascular events<sup>[3,4]</sup>. However, other studies have described a U-shaped relationship concerning weight, with severe obesity being associated with an increased risk of cardiovascular outcomes<sup>[5]</sup>. Due to the substantial weight loss noted with bariatric surgery, cardiovascular risk factors have been noted to be significantly reduced<sup>[6]</sup> however its effects on CVD outcomes, CVD-related mortality, and all-cause mortality remained largely unexplored.

The principal objective of this narrative review is to highlight the impact of bariatric surgery on cardiovascular outcomes based on the most current published data. Additionally, the narrative review d to determine if there are differences in cardiovascular outcomes across the various types of bariatric procedures.

### Study Selection

The major databases (PubMed, Medline, Scopus, Embase, google scholar, and Cochrane) were searched for original studies written in English. Original articles reporting CVD outcomes, CVD-related mortality, and all-cause mortality in obese patients following bariatric surgery, from October 2019 to September 2021 are included. (As there was a meta-analysis and systemic review in December 2019 studies before this date have been excluded.

### DISCUSSION

Although the various foods and dietary patterns<sup>[7,8]</sup> to aid in weight loss continue to be debated, given the global obesity crisis, bariatric surgery has gained favor over the last several decades as a viable alternative for weight loss. Obesity is a recognized risk factor for a wide range of health conditions<sup>[9,10]</sup> including coronary artery disease, arrhythmias, diabetes mellitus<sup>[11-15]</sup>, hypertension, arthritis, sleep apnea, and malignancies. It is known that food is occasionally used as a tool to counteract psychological stress, which appears to aggravate cardiovascular risk factors. It appears that stress, particularly in women<sup>[16]</sup>, is associated with an elevated risk for CVD problems<sup>[17-18]</sup>, which is exacerbated by the cardiometabolic disturbances caused by poor dietary choices and weight gain. An increasing body of research seeks to determine whether bariatric surgery reduces the risk of certain diseases through weight loss. Alterations in gut flora appear to have a role in obesity pathophysiology, predisposing to inflammation and infectious processes<sup>[19,20,21,22,18,8,23-45]</sup>. Metabolic alterations associated with obesity, such as hyperlipidemia, insulin resistance, and

hypertension (HTN), are separate important risk factors for the development of cardiovascular disease. The prevention and treatment strategies for obesity-related diseases concentrate on the foundations of weight loss, either by dietary changes or pharmaceutical therapies<sup>[44]</sup>. Moussa et al<sup>[46]</sup> conducted a large national study that matched 3,701 patients who had undergone bariatric surgery with 3,701 patients who had not undergone bariatric surgery. The primary outcome was a composite of fatal or non-fatal myocardial infarction (MI) and ischemic stroke. The secondary outcomes were fatal or non-fatal MI, fatal or non-fatal ischemic stroke, acute heart failure (HF), and mortality. The study showed that bariatric surgery patients had a significantly lower incidence of major adverse CVD events [hazard ratio (HR) 0.410, 95% confidence interval (CI) 0.274-0.615; P 0.001], driven primarily by a decrease in MI (HR 0.412, 95% CI 0.280-0.606; P 0.001), newly diagnosed HF, and mortality. Patients with preexisting cardiac disease, with or without type II diabetes mellitus (T2DM), had a lower incidence of MACE and mortality following metabolic surgery (sleeve gastrectomy or Roux-en-Y gastric bypass) than controls, according to one study<sup>[47]</sup> (Table 1).

These findings were further supported by a large nationwide Canadian study<sup>[48]</sup> involving 1319 people with prior ischemic heart disease or HF who underwent bariatric surgery and had a decreased MACE incidence following the surgery. Comparable findings have been validated in other studies<sup>[49,50]</sup>. The type of bariatric surgery was also explored, and it was learned that gastric bypass surgery was related to a lower incidence of CVD events as compared to sleeve gastrectomy in one study<sup>[51]</sup>. There are strong epidemiological associations between atrial fibrillation (Afib) and other conditions such as diabetes mellitus, and obesity with increased mortality and morbidity. Singh et al<sup>[33]</sup> assessed the effect of bariatric surgery on the recurrence of Afib after catheter ablation. Although the study failed to show a statistically significant lower recurrence rate or better arrhythmia-free survival in patients who underwent bariatric surgery before catheter ablation, it highlights an important clinical consideration that weight loss should be optimized before consideration of other invasive interventions to manage obesity-related disorders. The kidney transplant rates were found to be increased following bariatric surgery in a study by Sheetz et al<sup>[52]</sup> involving obese patients with end-stage kidney disease. The long-term outlook for patients with the end-stage renal disease remains dismal. This is primarily due to the high mortality rates associated with cardiovascular events including myocardial infarction and stroke, the risk of which may be mitigated by bariatric surgery<sup>[53]</sup>. In comparison to those with a normal BMI, patients with obesity are less likely to receive a kidney transplant<sup>[54]</sup>. Consequently, the increased kidney transplant rates observed in this study could be ascribed to weight loss. The study emphasizes the use of bariatric surgery to optimize body weight in patients who are otherwise kidney transplant candidates. Obesity predisposes to renal impairment by augmenting the risk of type 2 diabetes and microalbuminuria<sup>[55]</sup>. The pathogenesis of renal impairment in obese persons comprises inflammation, macrophage infiltration, activation of the sympathetic system, and renin-angiotensin systems resulting in hypertension<sup>[56]</sup>, insulin resistance, and hyperinsulinemia causing salt retention<sup>[57]</sup>. It has been postulated that these pathways are essential for the development of glomerular hyperfiltration, glomerulopathy, and albuminuria. Consequently, Liakopoulos et al<sup>[55]</sup> observed that the incidence rates of renal function, cardiovascular disease, and mortality were reduced following gastric bypass surgery (GPS). The authors concluded a noteworthy pattern of lower incidence of renal outcomes, including diabetic nephropathy, impairment in renal function, and renal function-related mortality, even after a mean follow-up of 4.5 years following GPS in patients with T2DM compared to comparable patients who had not undergone such surgical

treatment. The study further adds that a large weight loss is more strongly associated with a reduction in risk for cardiorenal-related outcomes (i.e., renal disease, heart failure, and CVD death) than for atherosclerotic disease (total CVD or nonfatal CVD), thus emphasizing the importance of obesity on cardiorenal pathways. Lastly, observed benefits appear to be largely consistent across all levels of renal function, indicating that "targeted" weight loss has the potential to reduce significant hazards in people with chronic kidney disease<sup>[55]</sup>.

**Table 1: Studies and their outcomes**

First Author	Year of publication	Study population	Study outcomes	Median Follow up post-surgery	Results	Types of Bariatric surgery
Osama Moussa et al <sup>[46]</sup>	2020	3701 cases	Primary outcome- fatal (F), non-fatal (NF) MI, and ischemic stroke  Secondary-F/NF MI, N/NF ischemic stroke, HF, and mortality	11.2 yrs.	Significantly lower occurrence of major adverse cardiovascular events- (HR) 0.410, 95% (CI) 0.274–0.615; P < 0.001].  Reduction in MI:(HR 0.412, 95% CI 0.280–0.606; P < 0.001), but not in stroke: (HR 0.536, 95% CI 0.164–1.748; P = 0.301)	NA

					A reduction was also observed in new diagnoses of heart failure (HR 0.403, 95% CI 0.181–0.897; P = 0.026) and mortality (HR 0.254, 95% CI 0.183–0.353; P < 0.001)	
Erik Stenberg et al <sup>[47]</sup>	2020	11,863 cases	Major cardiovascular events (MACE) (Acute coronary syndrome (ACS), stroke, sudden cardiac death)	61.1 +/- 30.4 mos: operated patients and 60.7 +/- 30.6 mos for non-operated individuals	lower risk for ACS events (adjusted HR 0.52, 95% CI 0.41–0.66, P < 0.001) and a lower risk for CVA (adjusted HR 0.81, 95% CI 0.63–1.01, P = 0.060) vs controls.	Sleeve gastrectomy (1,171 (9.9%))-8.9% had MACE.  Gastric bypass (10,692 (90.1%))-5.4% had MACE
Aristithes G. Doumouras et	2021	1319 cases (total cohort 2638) with	Primary outcomes- MACE (all-cause mortality, MI,	4.6 years	The primary outcome occurred in 11.5% (151/1319) of the surgery group vs 19.6% (259/1319) of the	Gastric bypass- 1049 (79.5%)

al <sup>[48]</sup>		underlying ischemic heart disease or HF	coronary revascularization, cerebrovascular events, and HF hospitalization).  The secondary outcome included 3-component MACE (MI, ischemic stroke, and all-cause mortality)		controls (adjusted [HR], 0.58 [95% CI, 0.48–0.71]; P<0.001).  The association was notable for those with HF (HR, 0.44 [95% CI, 0.31–0.62]; P<0.001  Ischemic heart disease (HR, 0.60 [95% CI, 0.48–0.74]; P<0.001  A lower incidence of the secondary outcome in the surgery group (HR, 0.66 [95% CI, 0.52–0.84]; P=0.001) and cardiovascular mortality (HR, 0.35 [95% CI, 0.15–0.80]; P=0.001)	Sleeve gastrectomy-296 (22.4%)
Ali Aminian et al <sup>[58]</sup>	2019	2287 cases with h/o DM (total cohort-13, 722)	extended MACE (composite of 6 outcomes), defined as the first occurrence of	3.9 years	Primary endpoint: (cumulative incidence at 8years, 30.8% [95% CI, 27.6%-34.0%] in the surgical group vs 47.7% [95% CI, 46.1%-	Roux-en-Y gastric bypass (n = 1443 [63%]), sleeve

			<p>all-cause mortality, coronary artery events, cerebrovascular events, heart failure, nephropathy, and atrial fibrillation.</p> <p>Secondary: 3-component MACE (MI, ischemic stroke, and mortality)</p>		<p>49.2%] in the nonsurgical group [P &lt; .001]</p> <p>All 7 prespecified secondary outcomes showed statistically significant differences in favor of metabolic surgery, including mortality.</p> <p>All-cause mortality: (cumulative incidence at 8 years, 10.0% [95% CI, 7.8%-12.2%] in surgery group vs 17.8% [95% CI, 16.6%-19.0%] in the control group</p>	<p>gastrectomy (n = 730 [32%]), adjustable gastric banding (n = 109 [5%]), and duodenal switch (n = 5)</p>
P. Singh <sup>[49]</sup>	2020	5170 cases and 9995 controls	<p>The incident composite CVD (IHD, HF, stroke, and TIA), all-cause mortality, hypertension, and AF</p>	3.9 years	<p>Bariatric surgery was not associated with a significantly lower CVD risk (adjusted (HR) 0.80; 95% CI; 0.62 to 1.02; P = 0.074) but was associated with a significant reduction in all-cause</p>	<p>CVD outcomes across various surgical groups:</p> <p>A gastric band (n=1965</p>

			were recorded	<p>mortality (aHR 0.70, 0.55 to 0.89; P = 0.004), HTN (adjusted HR 0.41, 0.34 to 0.50; P &lt; 0.001) and HF (aHR 0.57, 0.34-0.96; P = 0.033).</p> <p>Only the gastric bypass group had a significant reduction in CVD risk-(HR 0.53, 0.34 to 0.81; P = 0.003)</p>	<p>cases)- 45 (2.4%) vs 91 (2.5%), aHR1.07 (0.75, 1.54); 0.708</p> <p>Sleeve gastrectomy (n=1158 C)-14 (1.3%) vs 34 (1.6); aHR-0.80 (0.42, 1.52); 0.494</p> <p>Gastric bypass (n=2010) 27 (1.4) vs104 (2.9); aHR 0.53 (0.34, 0.81); 0.003</p>
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						Duodenal switch (n-37 cases)-1 (3%) vs 0(0)
Charles Pirlet et al <sup>[50]</sup>	2020	249 cases with known CAD vs 249 without known CAD	Primary endpoints- mortality (cardiac and noncardiac) and major adverse cardiocerebral events (MACCE), including all-cause death, MI, stroke, and myocardial revascularization at 30 days after bariatric surgery and throughout follow-up	7.4 years;	<p>mortality (mainly cardiac) was significantly higher in the CAD vs non-CAD (18% vs 10%, HR; 1.70, 95% CI: 1.03 to 2.79, p = 0.037)</p> <p>At 30 days-MACCE rate was significantly higher in the CAD vs non-CAD group (3.6% vs 0.4%, p = 0.011).</p> <p>After 30 days, MACCE rates remained significantly higher in the CAD group (30% vs 14%, HR 2.18, 95% CI: 1.45-3.28,</p>	

					p = 0.0002).	
Andrew M Brown et al <sup>[51]</sup>	2022	T=328,807, cases-60, 445, and 268, 362 control	CVD events - MI, and stroke; as well as a composite of both event		composite CVD decreased in the surgical group [HR = 0.48, 95% CI: 0.45-0.51], as did the risk of MI (HR = 0.39, 95% CI: 0.35- 0.42), and stroke (HR = 0.55, 95% CI: 0.51-0.59).	Sleeve gastrectomy patients had a higher risk of developing MI, stroke, and any type of CVD risk than gastric bypass patients.
Kyle H Sheetz et al <sup>[52]</sup>	2020	Cases-1597, control-4750	All-cause mortality at 5 years. Secondary outcomes included disease-specific mortality and incidence of a kidney transplant.	5 years	Reduced all-cause mortality at 5 yrs in surgery vs usual care group- 25.6% vs 39.8%; HR-0.69, 95% CI, 0.60-0.78), lower CVR-related mortality- cumulative incidence, 8.4% vs 17.2%; HR, 0.51; 95% CI, 0.41-0.65)  increase in kidney transplants at 5 years (cumulative incidence, 33.0% vs 20.4%; HR: 1.82; 95%	

					<p>CI, 1.58-2.09).</p> <p>However, at 1year, bariatric surgery was associated with higher all-cause mortality compared with usual care (cumulative incidence, 8.6% vs 7.7%; HR: 1.45; 95% CI, 1.13-1.85).</p>	
Vasileios Liakopoulos et al <sup>[55]</sup>	2020	5321 cases with DM and 5321 control	<p>Primary-assess renal function in terms of the development of microalbuminuria halved GRF compared to baseline renal disease development.</p> <p>Secondary-CV disease, HF, and</p>		<p>incidence rates relating to renal function, CV disease, and mortality were lower after the procedure, heart failure [HR] 0.33 [95% CI 0.24, 0.46]) and CV mortality (HR 0.36 [(95% CI 0.22, 0.58)]. The risk of a composite of severe renal disease or halved eGFR was 0.56 (95% CI 0.44, 0.71), whereas nonfatal CV risk was lowered less (HR 0.82 [95% CI 0.70, 0.97]) after bariatric</p>	<p>Assessed only effects of Roux-en-Y GBP and no other surgical procedures</p>

			mortality		procedure	
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## CONCLUSION

Obesity is a known risk factor for cardiovascular disease, diabetes mellitus, and kidney disorders, and research on the therapeutic benefits of bariatric surgery, particularly in terms of reducing and reversing the risk of these chronic diseases, is expanding. While diet plays a significant role in weight loss and there have been developments in the pharmaceutical sector to aid weight loss, bariatric surgery is a promising tool in not only assisting to lose weight efficiently and decisively but also in reducing and potentially reversing the risk of long-term health issues arising from excess weight gain and immobility. Although bariatric surgery carries its own risk of complications and necessitates closer monitoring for nutritional deficiencies, it promises to be an effective strategy for addressing the ever-growing obesity epidemic.

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