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IMPACT OF BARIATRIC SURGERY ON CARDIOVASCULAR RISK FACTORS: A NARRATIVE REVIEW

Bruno Makowski *(Corresponding Author, Email: brunomakowski000@gmail.com)*
Medical Center HCP, John Paul II Hospital, Poznań, Greater Poland, Poland
ORCID ID: 0009-0007-5806-0822

Oliwia Marciniak
Cardinal Stefan Wyszyński University in Warsaw, Warsaw, Poland
ORCID ID: 0009-0008-5282-2539

Dawid Szczepański
Independent Researcher, Warsaw, Poland
ORCID ID: 0009-0000-8430-0905

Grzegorz Jałoszyński
Cardinal Stefan Wyszyński University in Warsaw, Warsaw, Poland
ORCID ID: 0009-0004-3763-4311

Marcin Patryk Barbachowski
Cardinal Stefan Wyszyński University in Warsaw, Warsaw, Poland
ORCID ID: 0009-0008-4315-7477

Maciej Makarewicz
Independent Researcher, Warsaw, Poland
ORCID ID: 0000-0002-9099-8710

Anna Gwizdek
Independent Researcher, Warsaw, Poland
ORCID ID: 0009-0004-8037-6020

Natalia Bylak
Cardinal Stefan Wyszyński University in Warsaw, Warsaw, Poland
ORCID ID: 0009-0009-7405-9041

Norbert Gromadzki
Cardinal Stefan Wyszyński University in Warsaw, Warsaw, Poland
ORCID ID: 0009-0007-9954-6132

Sebastian Konecki
Cardinal Stefan Wyszyński University in Warsaw, Warsaw, Poland
ORCID ID: 0009-0006-0152-7914

Maria Kurt
Cardinal Stefan Wyszyński University in Warsaw, Warsaw, Poland
ORCID ID: 0009-0006-6820-4538

ABSTRACT

Obesity can be considered a global pandemic, already affecting a considerable and increasing number of adults. It has been described as one of the most important preventable causes of cardiovascular morbidity and mortality. Obesity accelerates the development and progression of cardiovascular disease through its strong correlations with hypertension, dyslipidemia, insulin resistance, type 2 diabetes mellitus, systemic inflammation, and adverse cardiac remodeling. Bariatric surgery, the current most effective long-term treatment for obesity, has increasingly been recognized as a metabolic intervention with benefits to the cardiovascular system. Accumulating evidence indicates that surgical weight loss is accompanied by rapid and sustained improvements in glycemic control, with high rates of diabetes remission, significant reductions in blood pressure, and favorable changes in lipid profiles. In parallel, bariatric procedures lead to attenuation of chronic low-grade inflammation, improvement in endothelial function, and regression of obesity-related cardiac structural abnormalities. Studies demonstrate a substantial reduction in major adverse cardiovascular events and cardiovascular mortality among surgically treated patients compared with matched nonsurgical controls. These benefits may result from both weight-dependent and weight-independent mechanisms, including alterations in gut hormones, bile acid metabolism, insulin sensitivity, and neurohormonal regulation. This narrative review aims to present the current evidence on the effects of bariatric surgery on established cardiovascular risk factors, discuss potential mechanistic pathways, types of bariatric procedures and emphasize the role of metabolic surgery as an effective strategy for reducing cardiovascular risk in individuals with obesity.

KEYWORDS

Bariatric Surgery, Obesity, Cardiovascular Disease, Metabolic Surgery

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1. Introduction

Obesity is currently recognized as one of the most prevalent chronic diseases worldwide and a major contributor to the global burden of cardiovascular disease. The World Health Organization (WHO) estimates that worldwide adult obesity has more than doubled since 1990, with billions of adults currently classified as overweight and hundreds of millions living with obesity globally (World Health Organization, retrieved January 2026). This dramatic epidemiological shift has been accompanied by a parallel increase in obesity-related comorbidities, particularly hypertension, type 2 diabetes mellitus (T2DM), dyslipidemia, and cardiovascular disease, which collectively account for a substantial proportion of premature mortality (GBD 2019 Risk Factors Collaborators, 2020; Powell-Wiley et al., 2021).

Obesity is no longer regarded as a condition of excess energy storage but rather as a complex, multisystem disorder characterized by profound disturbances in metabolic, inflammatory, and hormonal pathways. Adipose tissue functions as an active endocrine organ, secreting a wide array of inflammatory mediators that influence insulin sensitivity, vascular function, and immune responses (Blüher, 2019). Expansion of visceral adipose tissue is particularly harmful because it is strongly associated with many adverse cardiometabolic effects, including increased inflammatory activity, neurohormonal dysregulation, and ectopic lipid accumulation in non-adipose tissues such as the liver and myocardium, all of which contribute to elevated cardiovascular risk (Després et al., 2012). These alterations contribute to vascular dysfunction and atherosclerosis, thereby linking obesity, particularly excess visceral adiposity to the development and progression of coronary artery disease, heart failure, and stroke. This may explain why individuals with a metabolically unhealthy phenotype exhibit increased cardiovascular risk independent of overall adiposity or body mass index (Lavie et al., 2015).

Conventional management of obesity is based on lifestyle modification and pharmacotherapy. However, long-term weight loss and improvement of cardiometabolic risk factors are difficult to achieve with nonsurgical approaches, particularly in individuals with severe obesity (Apovian et al., 2015). In this context, bariatric surgery, also referred to as metabolic surgery has emerged as the most effective treatment for achieving substantial and sustained weight reduction. Beyond its impact on body mass, bariatric procedures induce significant hormonal and metabolic changes, such as alterations in hormones and bile acid metabolism, insulin sensitivity, and appetite regulation, leading to great improvements in glycemic control and other cardiovascular risk factors, often occurring before reaching maximal weight loss (Mingrone et al., 2021; Rubino et al., 2016).

Accumulating evidence from randomized controlled trials, large observational cohorts, and national registry studies indicates that bariatric surgery is associated with high rates of remission of T2DM, reductions in blood pressure, favorable changes in lipid profiles, and lower systemic inflammation (Schauer et al., 2017; Sjöström, 2013). Importantly, these improvements in individual risk factors are associated with a reduced incidence of major adverse cardiovascular events and lower cardiovascular mortality compared with matched nonsurgical populations (Aminian et al., 2019; Sjöström, 2013). Such findings have led to bariatric surgery being viewed not only as a weight-loss intervention but also as a disease-modifying therapy for cardiovascular risk.

The objective of this narrative review is to gather current evidence regarding the impact of bariatric surgery on established cardiovascular risk factors, including T2DM, hypertension, dyslipidemia, systemic inflammation, endothelial dysfunction, and cardiac structure and function. In addition, the review will examine potential biological mechanisms underlying these effects, compare outcomes among commonly performed surgical procedures, and summarize data on long-term cardiovascular morbidity and mortality. Through this comprehensive appraisal, we aim to clarify the role of metabolic surgery in cardiovascular risk reduction and to identify areas where further research is warranted.

2. Methodology

The review methodology was designed to provide a comprehensive, appraisal of peer-reviewed literature, including randomized controlled trials, observational cohort studies, meta-analyses, and systematic reviews. Unlike systematic reviews, a narrative approach allows integration of mechanistic insights, procedure-specific outcomes, and clinical implications within a broader context, which is particularly relevant for multifactorial interventions such as bariatric surgery. No formal quality assessment or risk-of-bias evaluation was performed. The authors declare no conflicts of interest.

Literature search was performed using PubMed and Scopus for articles published in English. The search strategy combined keywords and Medical Subject Headings (MeSH) related to obesity, bariatric surgery, and cardiovascular risk, including "bariatric surgery," "metabolic surgery," "Roux-en-Y gastric bypass," "sleeve gastrectomy," "adjustable gastric banding," "biliopancreatic diversion," "type 2 diabetes mellitus," "hypertension," "dyslipidemia," "inflammation," "endothelial function," "cardiac remodeling," and "cardiovascular outcomes." Studies were included if they evaluated the effects of bariatric surgery on one or more cardiovascular risk factors or reported long-term cardiovascular outcomes in adult populations. Exclusion criteria were non-human studies and publications in languages other than English. Greater emphasis was placed on studies with longer follow-up durations and larger sample sizes to enhance generalizability. Data extracted from included studies encompassed patient characteristics, type of bariatric procedure, follow-up duration, changes in glycemic control, blood pressure, lipid profile, inflammatory markers, endothelial function, cardiac structure, and long-term cardiovascular events. The evidence was gathered to highlight overall patterns, differences among surgical techniques, and mechanistic insights. This narrative approach allowed integration of clinical outcomes with underlying pathophysiological mechanisms, providing a comprehensive overview of the cardiovascular effects of bariatric surgery.

3. Results

3.1. Pathophysiological Links between Obesity and Cardiovascular Risk

Obesity is a complex, multifactorial condition that significantly increases cardiovascular risk through a combination of metabolic, hemodynamic, inflammatory, and structural mechanisms. Excess adiposity, particularly visceral fat accumulation, is strongly associated with insulin resistance, dyslipidemia, hypertension, and systemic inflammation, contributing to accelerated atherosclerosis and adverse cardiac remodeling (Lavie et al., 2017; Powell-Wiley et al., 2021). Adipose tissue functions as an active endocrine organ, secreting a variety of biologically active molecules, such as adipokines, cytokines, and chemokines, which influence arterial stiffness, glucose metabolism, and inflammatory responses (Blüher, 2019; Powell-Wiley et al., 2021). In obesity, the balance of these secreted factors shifts toward a proinflammatory state, characterized by elevated levels of interleukin-6 (IL-6), tumor necrosis factor-alpha (TNF-α), and C-reactive protein (CRP), leading to increased atherosclerosis (Lee & Pratley, 2005). This chronic inflammation is associated with increased arterial stiffness, diminished bioavailability of nitric oxide, and endothelial dysfunction, all of which are indicators of cardiovascular disease (Powell-Wiley et al., 2021). Insulin resistance plays a central role in the development of type 2 diabetes mellitus and contributes independently to cardiovascular risk. Obesity promotes endothelial dysfunction, increased sympathetic nervous system activity, and activation of the renin-angiotensin-aldosterone system, leading to sodium retention (Powell-Wiley et al., 2021). Dyslipidemia commonly observed in obese individuals is characterized by elevated triglycerides, low high-density lipoprotein cholesterol (HDL-C), and the presence of small dense low-density lipoprotein cholesterol (LDL-C) particles, further accelerates atherogenesis (Després, 2012). In addition, obesity-related structural changes in the heart, including left ventricular hypertrophy, concentric remodeling, and increased epicardial fat deposition, contribute to the development of heart failure (Lavie et al., 2017).

The interplay between these metabolic, inflammatory, and structural mechanisms establishes a complicated pathway linking obesity to cardiovascular morbidity and mortality. By understanding these pathophysiological processes, the beneficial effects of bariatric surgery on cardiovascular risk factors can be better contextualized. Surgical interventions that reduce adiposity not only decrease mechanical strain on the cardiovascular system, but also induce hormonal and metabolic changes improving the overall cardiovascular risk profile.

Effects of Bariatric Surgery on Individual Cardiovascular Risk Factors

Bariatric surgery has been consistently shown to induce substantial improvements in a broad range of cardiovascular risk factors, effects that extend beyond those attributable to weight loss alone. These benefits are observed across different surgical techniques, although the magnitude and durability of improvement may vary depending on the procedure performed, baseline patient characteristics, and duration of follow-up.

Effects on Glucose Metabolism and Type 2 Diabetes Mellitus

Improvements in glucose homeostasis represent one of the strongest and earliest cardiovascular benefits of bariatric surgery. Numerous randomized controlled trials and observational studies have demonstrated high rates of remission or significant improvement of T2DM following surgical intervention. Long-term diabetes remission rates up to 37.5% have been reported during 10-year follow-up in surgically treated patients (Schauer et al., 2017; Mingrone et al., 2021). Improvements in glycemic control have been observed within days to weeks after bariatric surgery, occurring before substantial weight loss, which suggests the involvement of weight-independent mechanisms. Proposed mechanisms include enhanced incretin secretion, particularly glucagon-like peptide-1 (GLP-1) as well as alterations in bile acid signaling and other gut-mediated metabolic pathways (Latteri et al., 2023). Given the strong association between T2DM and cardiovascular disease, sustained glycemic improvement after bariatric surgery has major implications for cardiovascular risk reduction. Long-term studies indicate that surgically treated patients experience a lower incidence of microvascular and macrovascular complications compared with those receiving intensive medical therapy alone (Aminian et al., 2019).

Effects on Blood Pressure and Hypertension

Hypertension is highly prevalent among individuals with obesity and represents a major modifiable cardiovascular risk factor. Bariatric surgery is associated with significant reductions in both systolic and diastolic blood pressure, as well as decreased reliance on antihypertensive medications. Meta-analyses have reported hypertension remission rates of approximately 51-61.7%, with additional patients experiencing clinically meaningful improvements despite not meeting criteria for remission (Buchwald et al., 2009; Schiavon et al., 2018). The mechanisms underlying blood pressure reduction include decreased sympathetic nervous system activity, reduced activation of the renin-angiotensin-aldosterone system, decreased sodium retention, and improved endothelial function, in addition to reductions in body weight and visceral adiposity (Powell-Wiley et al., 2021).

Effects on Lipid Metabolism

Bariatric surgery is associated with significant improvement in hyperlipidemia and favorable changes in lipid and lipoprotein profiles. In a large meta-analysis, Buchwald et al. reported that hyperlipidemia improved in approximately 70% or more of patients following bariatric surgery. Significant improvements in lipid profile after surgery and remission rates of dyslipidemia may correspond with the extent of intestinal bypass. Mixed restrictive-malabsorptive procedures, such as biliopancreatic diversion with or without duodenal switch and Roux-en-Y gastric bypass, have been associated with greater rates of dyslipidemia improvement compared with purely restrictive procedures. These improvements occur early in the postoperative period and have been shown to persist throughout follow-up in available studies (Piché et al., 2021).

Effects on Systemic Inflammation

Chronic inflammation is an important mediator linking obesity to cardiovascular disease (Powell-Wiley et al., 2021). Bariatric surgery leads to significant and sustained reductions in visceral adipose tissue mass leading to decreases in circulating inflammatory markers such as C-reactive protein, tumor necrosis factor-alpha, and interleukin-6 (Latteri et al., 2023). The decrease in inflammation is thought to contribute to improvements in many fundamental aspects of atherosclerosis such as fatty streak development, atherothrombosis and endothelial function (Powell-Wiley et al., 2021).

Effects on Endothelial Function and Vascular Health

Endothelial dysfunction is a critical step in the development of atherosclerosis. Studies assessing vascular function after bariatric surgery have demonstrated improvements in flow-mediated dilation (FMD) and carotid intima media thickness (CIMT) correlating with post-surgery weight loss. These changes are indicative of improved vascular health and are observed as early as 1 month after surgery in case of FMD and 3 months after surgery in case of CIMT (Li et al., 2025).

Effects on Cardiac Structure and Function

Obesity is associated with structural and functional alterations of the heart, including cardiac enlargement, left and right ventricular hypertrophy, left atrial dilatation, concentric remodeling, and systolic/diastolic dysfunction. Bariatric surgery has been shown to induce regression of left ventricular hypertrophy, improvement in left ventricular geometry and diastolic function filling parameters, and reductions in epicardial adipose tissue. These changes may translate into improved cardiac efficiency and reduced risk of heart failure (Cuspidi et al., 2014).

Effects on Bile Acid Metabolism

Bariatric surgery induces changes in bile acid metabolism, thus increasing insulin sensitivity and reducing gluconeogenesis through increased secretion of molecules such as GLP-1 and activation of TGR-5. These mechanisms may induce improvements in glucose metabolism. It has been reported that bariatric surgery (RYGB) leads to reduction of faecal bile acids causing changes in microbiota composition leading to further improvements in bile acid metabolism inducing positive effects on metabolic syndrome (Latteri et al., 2023).

Collectively, the improvement of these individual cardiovascular risk factors following bariatric surgery provides a mechanistic basis for the observed reduction in major adverse cardiovascular events and cardiovascular mortality.

3.2. Procedure-specific Differences in Cardiovascular Risk Factor Reduction

The percentages of different types of bariatric procedures vary worldwide. Globally, sleeve gastrectomy (SG) and Roux-en-Y gastric bypass (RYGB) account for the vast majority of bariatric procedures, while adjustable gastric banding (AGB) and biliopancreatic diversion with or without duodenal switch (BPD/DS) are performed less frequently. According to international registry data, SG currently represents 45.9% of all bariatric procedures worldwide, followed by RYGB at 39.6%, AGB at 7.4%, and BPD/DS accounting for 1.1% of cases (Angrisani et al., 2017).

Sleeve Gastrectomy

Sleeve Gastrectomy (SG) has become the most commonly performed bariatric procedure largely due to its technical simplicity and favorable safety profile. It is associated with substantial weight loss and marked improvements in cardiovascular risk factors. This approach to bariatric surgery may in some aspects produce results comparable to traditionally considered reference procedure, RYGB. SG achieves better outcomes than purely restrictive procedures. Among patients with baseline, pre-surgery glycated hemoglobin of approximately 9.2%, the reported T2DM remission rate defined as glycated hemoglobin of 6% or less without pharmacological diabetes treatment 5 years post-SG is above 20%. Furthermore SG improved glycemic control and allowed for reductions in pharmacological treatments in other patients. Hypertension remission rates following SG range from 55-82%. SG has a neutral effect on LDL concentration and less pronounced impact on overall lipid profile which is a key disadvantage of SG in comparison to more malabsorptive techniques. SG is a shorter and less complex procedure than RYGB, bringing much smaller risk of nutritional deficiencies. Overall, SG provides substantial cardiovascular risk reduction, largely mediated by weight loss and improved insulin sensitivity (Benaiges et al., 2015; Schauer et al., 2017).

Roux-en-Y Gastric Bypass

Roux-en-Y Gastric Bypass (RYGB) has consistently demonstrated superior effects on several cardiovascular risk factors compared with restrictive procedures. In a randomized trial with 10-year follow-up, approximately 25% of patients assigned to RYGB maintained T2DM remission, defined as glycated hemoglobin <6.5% and fasting glycaemia <5.55 mmol/L without pharmacological therapy for at least 1 year (Mingrone et al., 2021). A substantial reduction in the number of antihypertensives has been observed in approximately 60% of patients 12 months post-RYGB (Schiavon et al., 2018). RYGB is also associated with improvements in lipid metabolism, including reductions in low-density lipoprotein cholesterol (LDL-C) of 17-20%. When comparing RYGB to SG in terms of cardiovascular risk factors clinical outcomes suggest that RYGB and SG result in similar weight loss. RYGB is slightly more effective in the treatment of T2DM and hypertension. The more noticeable difference is the impact on dyslipidemia in favor of RYGB (Benaiges et al., 2015).

Adjustable Gastric Banding

Adjustable gastric banding (AGB) is the third most performed bariatric surgery. AGB is performed less and less largely due to inferior long-term weight loss (Angrisani et al., 2017; Kang & Le, 2017). Studies have shown that AGB is associated with in approximately half the weight loss of gastric bypass. The impact of cardiovascular risk factors such as diabetes mellitus, hypertension and dyslipidemia of AGB is also inferior (Shimada et al., 2019). The advantages of AGB are the reversibility of the procedure and the adjustability of the band according to patient needs (Kang & Le, 2017).

Biliopancreatic Diversion With or Without Duodenal Switch

Biliopancreatic Diversion (BPD), although performed in fewer than 2% of patients, may be associated with profound improvements in cardiovascular risk factors. The highest long-term type 2 diabetes mellitus remission rates of 50% have been reported during the 10-year follow-up in patients post-BPD (Mingrone et al., 2021). BPD is a surgical approach resulting in the highest malabsorptive effect. This is associated with reductions in some of the cardiovascular risk factors such as 50% LDL reduction, compared to 17-20% in RYGB. High degree of malabsorption also induces high rates of severe adverse events such as dumping syndrome, marginal ulcers. Although BPD is rarely performed nowadays, it was crucial in the development of SG, which was originally intended as the restrictive component of BPD (Benaiges et al., 2015; Mingrone et al., 2021).

Comparative Implications for Cardiovascular Risk Reduction

When comparing procedures, RYGB and SG provide the most favorable balance between cardiovascular risk reduction and safety for the majority of patients. RYGB appears to have more pronounced, superior improvements in dyslipidemia and less pronounced benefits in terms of diabetes remission, while SG offers comparable benefits for blood pressure with lower procedural complexity. AGB provides more limited cardiovascular benefit but is relatively simple to perform and leads to less adverse events. BPD offers the greatest metabolic improvements at the cost of increased risk due to the high malabsorptive effects of the procedure. These distinctions underscore the importance of individualized surgical selection based on baseline cardiovascular risk, metabolic disease severity, and patient-specific factors.

3.3 Long-term Cardiovascular Outcomes and Mortality After Bariatric Surgery

Beyond improvements in individual cardiovascular risk factors, the ultimate clinical relevance of bariatric surgery lies in its association with reduced incidence of major adverse cardiovascular events (MACE) and cardiovascular mortality. Over the past two decades, large population-based cohort studies and analyses have provided robust evidence that surgically induced weight loss translates into meaningful long-term cardiovascular benefit when compared with conventional medical management of obesity.

One of the most influential bodies of evidence comes from the Swedish Obese Subjects (SOS) study, a prospective, controlled cohort study with long-term follow-up extending beyond 20 years. In this study, bariatric surgery was associated with a significant reduction in cardiovascular mortality compared with matched obese controls receiving usual pharmacological care, with relative risk reductions of approximately 30%. Notably, the reduction in cardiovascular events occurred even despite the absence of complete normalization of body weight, underscoring the importance of metabolic and hemodynamic improvements rather than weight loss alone (Sjöström, 2013).

More recent observational studies have corroborated these findings. In a retrospective matched-cohort study including over 13,000 study participants with T2DM and obesity, bariatric surgery was associated with a significantly lower rate of extended MACE (6-component composite including all-cause mortality, coronary events, cerebrovascular events, heart failure, nephropathy, and atrial fibrillation) of 30.8% compared with 47.7 % in nonsurgical controls, resulting in 8-year absolute risk difference (ARD) of 16.9%. Reduction in 3-component MACE (consisting of cardiovascular death, non-fatal myocardial infarction and non-fatal stroke events) has been reported showing ARD of 10.6% (27.6 - 17.0%). During the 8-year follow-up 10% of surgically treated patients died and 17.8% of non-surgically treated patients died resulting in ARD of 7.8% (Aminian et al., 2019).

Procedure-specific differences in long-term cardiovascular outcomes have also been observed. Evidence suggests that RYGB may result in greater protection against MACE than restrictive procedures, particularly in patients with pre-existing type 2 diabetes mellitus. RYGB was associated with lower risk of diabetes, cardiovascular disease, nephropathy and greater reduction of body weight compared with SG (Aminian et al., 2021). Data on long-term cardiovascular outcomes following BPD is more limited due to the low prevalence of this procedure; however, available evidence suggests substantial risk reduction, consistent with its profound effects on metabolic risk factors (Mingrone et al., 2021).

Heart failure outcomes represent another important dimension of cardiovascular benefit following bariatric surgery. Obesity is a major risk factor for heart failure mostly associated with diastolic dysfunction and adverse myocardial remodeling such as left ventricular hypertrophy. In small observational cohorts of patients with pre-existing systolic heart failure, bariatric surgery has been associated with increases in LVEF of approximately 14 percentage points at a mean follow-up of approximately 13 months, however, data is limited and derived from small, non-randomized studies (Vest et al., 2012).

4. Discussion

4.1. Limitations of the Current Evidence

Despite growing evidence supporting the beneficial cardiovascular effects of bariatric surgery, several important limitations must be considered when interpreting the available evidence. First, much of the data linking bariatric surgery to reduced cardiovascular morbidity and mortality is derived from observational cohort studies and registry-based analyses rather than randomized controlled trials (RCTs). Although these studies often employ robust matching techniques and multivariable adjustment, residual confounding and selection bias cannot be completely excluded. Patients who undergo bariatric surgery may differ systematically from those receiving nonsurgical care with respect to health-seeking behavior, socioeconomic status, and access to healthcare, all of which may independently influence cardiovascular outcomes (Aminian et al., 2019).

Heterogeneity in study populations, surgical techniques, and outcome definitions limits direct comparison across studies. Bariatric procedures have evolved substantially over time, with changes in surgical technique, perioperative care, and patient selection criteria. Consequently, outcomes reported in earlier studies may not fully reflect contemporary practice, particularly for procedures such as SG, which has gained widespread adoption only in the past decade. In addition, variability in definitions of remission for conditions such as hypertension and type 2 diabetes mellitus complicates the synthesis of results across studies (Schauer et al., 2017).

Long-term follow-up data remain limited for certain procedures, particularly BPD, due to their relatively low prevalence. While these procedures appear to confer the most profound metabolic and cardiovascular benefits, their long-term safety profile, nutritional, malabsorptive consequences, and cardiovascular outcomes are less well characterized compared with more commonly performed operations such as RYGB and SG (Mingrone et al., 2021). Similarly, data on cardiovascular outcomes beyond 10-15 years remain sparse for many contemporary surgical techniques.

Another important limitation relates to the assessment of cardiovascular outcomes. Relatively few studies have focused on specific cardiovascular phenotypes, such as heart failure with preserved ejection fraction or atrial fibrillation, conditions that are highly prevalent in individuals with obesity and may respond differently to surgical intervention (Vest et al., 2012). The mechanisms linking bariatric surgery to improvements in these conditions are still not fully understood.

Finally, disparities in access to bariatric surgery and underrepresentation of certain populations in clinical studies limit the generalizability of findings. Racial and ethnic minorities, older adults, and individuals of lower socioeconomic status are often underrepresented in bariatric cohorts, despite experiencing a disproportionate burden of obesity-related cardiovascular disease (Powell-Wiley et al., 2021). Addressing these disparities is essential to ensure equitable application of metabolic surgery as a cardiovascular risk reduction strategy.

Recognizing these limitations is critical for contextualizing current evidence and for guiding future research.

4.2. Future Directions and Clinical Implications

Future research on bariatric surgery and cardiovascular risk reduction should aim to address existing gaps in evidence and refine the role of metabolic surgery within cardiovascular prevention strategies. Although current data strongly support the cardiometabolic benefits of bariatric surgery, additional high-quality studies are needed to better define patient selection criteria, procedure-specific effects, and long-term outcomes across diverse populations.

More randomized controlled trial data with cardiovascular endpoints should be of highest priority. While large observational studies provide compelling evidence of reduced cardiovascular morbidity and mortality, randomized trials comparing bariatric surgery with contemporary medical and lifestyle interventions and incorporating hard cardiovascular outcomes would strengthen causal inference. Given the logistical challenges of long-term randomization in this context, pragmatic trial designs and hybrid effectiveness-implementation studies may offer feasible alternatives.

Greater emphasis should also be placed on understanding procedure-specific cardiovascular effects. Comparative effectiveness studies directly evaluating SG, RYGB, and less commonly performed procedures with standardized definitions of cardiovascular risk factor remission and event outcomes would help clarify optimal surgical strategies for patients with varying degrees of metabolic and cardiovascular risk. In particular, further investigation is needed to determine whether certain procedures provide superior protection against specific outcomes, such as heart failure or stroke, and whether these benefits persist over extended follow-up periods.

Mechanistic studies represent another critical area for future research. Advances in metabolomics, proteomics, and microbiome analysis provide opportunities to better characterize the biological pathways through which bariatric surgery influences cardiovascular physiology. Despite the complexity of obesity and its many metabolic implications, isolating specific factors can help clarify the underlying mechanisms. Improved understanding of gut hormone signaling, bile acid metabolism, and inflammatory pathways may facilitate the development of less invasive therapeutic strategies that replicate some of the cardioprotective effects of bariatric surgery with less risk.

From a clinical perspective, integrating bariatric surgery into cardiovascular risk management requires a multidisciplinary approach involving cardiologists, endocrinologists, surgeons, and primary care providers. Early referral for surgical evaluation may be particularly beneficial for patients with severe obesity and poorly controlled cardiovascular risk factors, especially those with type 2 diabetes mellitus or established cardiovascular disease. Incorporating cardiovascular risk assessment tools into preoperative evaluation may help identify patients most likely to derive long-term cardiovascular benefit from surgery.

Finally, addressing disparities in access to bariatric surgery and postoperative care is essential to maximize population-level cardiovascular benefit. Efforts to improve insurance coverage, expand access to specialized centers, and enhance long-term follow-up and nutritional monitoring are critical for ensuring that the cardiovascular benefits of bariatric surgery are equitably realized. Continued research focused on underrepresented populations will be necessary to ensure that findings are generalizable and applicable across diverse demographic and clinical contexts.

5. Conclusions

Bariatric surgery represents a highly effective intervention for the management of obesity and its associated cardiovascular risk factors. A substantial body of evidence demonstrates that surgical weight loss is accompanied by significant and sustained improvements in glycemic control, blood pressure, lipid profiles, systemic inflammation, endothelial function, and cardiac structure and function. These benefits extend beyond weight reduction alone and reflect complex metabolic, hormonal, and neurohormonal, surgically induced changes in gastrointestinal anatomy.

Differences in cardiovascular risk factor reduction are evident among bariatric procedures. RYGB and SG, which together account for the vast majority of bariatric surgeries performed worldwide, provide the most favorable balance between efficacy and safety for most patients. RYGB appears to confer greater improvements in dyslipidemia and higher rates of type 2 diabetes mellitus remission, whereas SG offers comparable benefits for blood pressure and overall cardiovascular risk reduction with a simpler surgical profile. Less commonly performed procedures, such as BPD, are associated with the most profound metabolic and cardiovascular improvements but are limited by higher risks of nutritional deficiencies and adverse events. AGB, now infrequently used, provides more modest and less durable cardiovascular benefits.

Importantly, improvements in individual cardiovascular risk factors following bariatric surgery translate into meaningful reductions in major adverse cardiovascular events, heart failure, and cardiovascular mortality, as demonstrated in large long-term observational studies. Although most outcome data are derived from nonrandomized studies, the consistency of findings across diverse populations and healthcare systems supports the role of bariatric surgery as a disease-modifying therapy for cardiovascular risk. The convergence of weight-dependent and weight-independent mechanisms including reduced visceral adiposity, improvements in insulin sensitivity, favorable modulation of gut hormone and bile acid signaling, reduction of systemic inflammation, and improved cardiac structure and function provides a strong biological rationale for these clinical benefits.

Despite these advances, important gaps in knowledge remain. Future research should focus on long-term, procedure-specific cardiovascular outcomes, improved mechanistic understanding, and the inclusion of diverse and underrepresented populations. From a clinical standpoint, bariatric surgery should be considered an integral component of cardiovascular risk management in appropriately selected patients with severe obesity, particularly those with type 2 diabetes mellitus or multiple cardiometabolic risk factors. As evidence continues to evolve, metabolic surgery is likely to play an increasingly central role in strategies aimed at reducing the global burden of obesity-related cardiovascular disease.

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