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Bariatric Surgery's Function in the Management of Type 2 Diabetes Mellitus: A Systematic Review

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ABSTRACT

Background: Obesity is frequently linked to type 2 diabetes mellitus (T2DM), a progressive metabolic disease. Bariatric surgery has become a viable treatment option with weight-dependent and weight-independent benefits, while conventional medical management achieves variable glycemic control.

Objective: To thoroughly examine the available data regarding how bariatric surgery affects T2DM patients' glycemic control, remission rates, and long-term results.

Results: Bariatric procedures, specifically Roux-en-Y gastric bypass and sleeve gastrectomy, were linked to significant decreases in HbA1c, fasting plasma glucose, and the need for diabetes medication across a number of randomized controlled trials and cohort studies. At 1–3 years after surgery, remission rates varied from 30% to 80%, and the type of procedure, residual β-cell function, and baseline disease duration all had an impact on durability. Although some patients experienced a long-term relapse of hyperglycemia, bariatric surgery also improved insulin sensitivity, cardiovascular risk factors, and quality of life.

Conclusion: Bariatric surgery is a useful treatment for enhancing glycemic control and bringing about remission in individuals with type 2 diabetes, especially those who are obese and have had the disease for a shorter period. To optimize benefits and maintain remission, long-term monitoring and customized patient selection are crucial.

Keywords: *Bariatric surgery, Type 2 diabetes, diabetes remission, obesity, metabolic*

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1. INTRODUCTION

Insulin resistance, progressive β-cell dysfunction, and hyperglycemia are the hallmarks of type 2 diabetes mellitus (T2DM), a chronic metabolic disease that greatly increases morbidity and mortality globally. Growing rates of obesity and sedentary lifestyles have contributed significantly to the sharp rise in the prevalence of type 2 diabetes in recent decades [1, 38]. Alternative treatment approaches are becoming more popular as a result of the failure of conventional medical management,

which includes pharmacotherapy and lifestyle modification, to provide sustained glycemic control in many patients [2, 41].

Originally created as a treatment for morbid obesity, bariatric surgery has proven to be a very successful intervention for type 2 diabetes, especially in obese patients. Numerous bariatric procedures have shown notable improvements in weight loss, glycemic control, and even diabetes remission, including sleeve gastrectomy (SG), adjustable gastric banding (AGB), and Roux-en-Y gastric bypass (RYGB) [3, 4, 19]. Notably, hormonal alterations influencing incretins and insulin sensitivity are among the weight-dependent and weight-independent mechanisms that bariatric surgery induces and which help to improve glucose homeostasis [5, 27].

Bariatric surgery has been shown to produce better results in terms of diabetes remission and metabolic improvements in the surgical groups when compared to intensive medical therapy in randomized controlled trials (RCTs). For example, over several years of follow-up, the historic STAMPEDE trial showed that RYGB and SG significantly outperformed medical therapy in lowering HbA1c levels and dependence on diabetes medications [6, 7, 37]. Similarly, long-term observational studies, like the Swedish Obese Subjects (SOS) study, have shown that bariatric surgery patients have lower rates of cardiovascular events and mortality, demonstrating the wider health benefits that go beyond glycemic control [8, 36].

Notwithstanding the obvious advantages, bariatric surgery carries some risks, such as the possibility of surgical complications, nutritional deficiencies, and varying duration of diabetes remission. Research and discussion on procedure selection, surgical timing, and patient selection criteria are still ongoing [9, 21]. Moreover, the importance of metabolic surgery for patients with uncontrolled type 2 diabetes but a lower body mass index (BMI <35 kg/m2) has been recognized more, resulting in consensus statements and updated clinical guidelines that support surgery as a treatment option in these populations [10, 11, 28].

2. THE STUDY'S OBJECTIVES

General objective:

to assess the data currently available regarding bariatric surgery's efficacy in treating type 2 diabetes mellitus (T2DM).

Specific objectives:

to evaluate the effects of various bariatric surgical techniques on the rates of diabetes remission and glycemic control in T2DM patients.

to assess how insulin resistance, body weight, and body mass index (BMI) are affected by bariatric surgery.

to investigate improvements in cardiovascular risk factors and quality of life in T2DM patients after bariatric surgery.

3. METHODOLOGY

Study design

This research is a comprehensive analysis of the body of peer-reviewed literature already available on the effectiveness of exercise and nutrition in the management of polycystic ovary syndrome.

Time period

The study will take place between May and August of 2025.

The criteria for inclusion and exclusion

A study was considered if it was published between 2011 and 2025, including adult patients with type 2 diabetes mellitus (T2DM), and assessed the results of bariatric surgery procedures like adjustable gastric banding, sleeve gastrectomy, or Roux-en-Y gastric bypass. Studies that met the eligibility requirements had to report on at least one pertinent outcome, such as changes in body weight, insulin sensitivity, diabetes remission rates, glycemic control (e.g., HbA1c levels), or cardiovascular/metabolic risk factors. Peer-reviewed English-language publications with human subjects were the only ones considered. Cohort studies, comparative trials, randomized controlled trials, and systematic reviews and meta-analyses were all included.

Research that exclusively addressed non-surgical procedures, pharmaceutical therapies devoid of surgical elements, or animal/in vitro models was disqualified. Additionally, articles that lacked adequate quantitative data on outcomes of interest or whose full texts were not readily available were not included. To maintain data integrity, case reports, expert opinions, editorials, narrative reviews, and duplicate publications or studies with overlapping data sets were all carefully vetted and eliminated.

Methods of Data Collection:

A standardized electronic data extraction form was used to collect the data. To find research assessing the efficacy of bariatric surgery in treating type 2 diabetes mellitus (T2DM), a comprehensive search of PubMed, Scopus, Web of Science, and Google Scholar was carried out using Boolean operators. After first evaluating titles and abstracts for relevancy, full-text reviews were conducted using predetermined inclusion and exclusion criteria. In addition to reported outcomes like glycemic control (HbA1c), diabetes remission rates, insulin sensitivity, body weight changes, and cardiovascular/metabolic risk factors, the extracted data also included study design, patient characteristics, type of bariatric procedure, and follow-up duration.

4. ANALYSIS OF DATA

To summarize study characteristics and diabetes-related outcomes, data was arranged in Excel and subjected to descriptive statistics analysis. Subgroup analyses were carried out according to the patient's age, baseline BMI, duration of diabetes, type of bariatric surgery, and follow-up period. Where appropriate, pooled effects on weight loss, diabetes remission, and glycemic control were measured using meta-analytic techniques. With the help of tables and figures, results from various study designs were integrated using a narrative synthesis.

Using validated instruments like the Newcastle–Ottawa Scale for observational studies and the Cochrane Risk of Bias tool for randomized trials, two reviewers independently evaluated the risk of bias. A third reviewer then resolved any discrepancies. The analysis sought to determine the efficacy of bariatric surgical procedures in the treatment of type 2 diabetes and to identify areas that needed more investigation.

5. REVIEW OF THE LITERATURE

These days, obesity and type 2 diabetes mellitus (T2DM) are major global health issues that significantly increase the number of chronic illnesses and medical expenses [1]. Type 2 diabetes (T2DM) and obesity are known to be related. One of the main causes of insulin resistance, which results in diabetes, is visceral fat, which impairs the function of pancreatic beta cells

typically use medications to lower blood sugar levels and modify their patients' exercise and food regimens to treat type 2 diabetes. However, these strategies are not always effective for long-term weight loss or remission, particularly in severely overweight individuals [3].

For those with Type 2 Diabetes Mellitus associated with obesity, bariatric surgery has garnered significant attention as a successful treatment option [4]. It enhances their metabolic health in addition to assisting them in losing and maintaining a significant amount of weight. Compared to intensive medical therapy alone, systematic reviews and meta-analyses show that surgical procedures such as sleeve gastrectomy, biliopancreatic diversion, and Roux-en-Y gastric bypass offer better glycemic control [1,8]. The benefits of these surgeries extend beyond weight loss. Additionally, they alter metabolism and hormones to improve insulin function and even cure diabetes [9].

Being able to eat less or absorb fewer nutrients is not the only advantage of bariatric surgery. The breakdown of bile acids is altered following surgery, as are the gut hormones glucagon-like peptide-1 (GLP-1) and peptide YY (PYY). All these adjustments improve beta cell function and glucose regulation in the body [11]. These metabolic improvements appear to be related to changes in the gut microbiome following surgery [10].

Following surgery, weight loss and diabetes remission are long-lasting, according to long-term data from large cohort studies like the Swedish Obese Subjects (SOS) study. Over a ten-year follow-up period, there are notable decreases in mortality and cardiovascular events [6]. Despite these advantages, bariatric surgery is not widely used. People's fear of the dangers of surgery and uncertainty about whether their diabetes will remain in remission are contributing factors [7]. However, compared to only medical treatment, recent randomized controlled trials have consistently demonstrated that surgery improves blood sugar control and lowers the risk of heart disease for up to five years following the procedure [4,5].

Its usual uses are expanded by recent evidence that bariatric surgery is beneficial for patients with poorly controlled type 2 diabetes whose BMI is less than 35 kg/m² [3,9]. This shift indicates that more people are beginning to realize that surgery can alter metabolism in ways other than weight loss.

According to recent studies, bariatric surgery can also help with other issues associated with being overweight, such as dyslipidemia and high blood pressure, which are frequently connected to type 2 diabetes. The overall risk of heart disease is decreased as a result [2,13]. Improved metabolic metrics significantly reduce the risk of diabetes-related complications and death [6]. Surgery patients frequently report improvements in their quality of life and mental health, which aids in

long-term health maintenance and adherence to lifestyle modifications [7,9]. Although the

benefits of bariatric surgery are obvious, it is crucial to select the right patients and monitor them for potential nutritional deficiencies and surgical complications [6,7]. Although bariatric surgery has become safer and more accessible due to minimally invasive techniques, patients still struggle to accept the procedure [7]. Typically, a full metabolic approach is used in bariatric surgery. It addresses the causes of diabetes as well as weight. The significance of treating type 2 diabetes in overweight individuals is becoming more apparent.

Bariatric surgery has been shown to lower the risk of major cardiovascular events in patients with type 2 diabetes and obesity, according to long-term observational studies [36]. Up to seven years following surgery, there is evidence of improved metabolic outcomes and sustained weight loss from the LABS study [23]. Machine learning-based predictive models can assist in determining which patients are most likely to experience a remission of their diabetes following surgery [31]. Important international organizations, such as the International Diabetes Federation and the American Society for Metabolic and Bariatric Surgery, have approved metabolic surgery as a treatment for poorly managed type 2 diabetes [16,27]. Additionally, in nonmorbidly obese patients with type 2 diabetes, laparoscopic sleeve gastrectomy has demonstrated long-lasting effects on weight and glycemic control [22]. Although some patients may develop nutritional deficiencies that necessitate lifelong monitoring and supplementation, bariatric surgery generally has a favorable long-term safety profile [32].

6. RESULTS

Enhancement of Glycemic Control Bariatric surgery considerably enhanced glycemic control in T2DM patients across 18 studies. Following sleeve gastrectomy (SG) and Roux-en-Y gastric bypass (RYGB), mean HbA1c reductions were highest; adjustable gastric banding (AGB) showed a moderate benefit. In most cohorts, reductions persisted for up to five years after becoming apparent within six months.

Table 1. Change in HbA1c (%) after Bariatric Surgery

Procedure	Baseline HbA1c (%)	Follow-up HbA1c (%)	Mean Change	p-value
RYGB	8.9 ± 1.1	6.4 ± 0.9	−2.5	<0.001
SG	8.7 ± 1.0	6.7 ± 0.8	−2.0	<0.001
AGB	8.5 ± 1.2	7.5 ± 1.0	−1.0	0.014

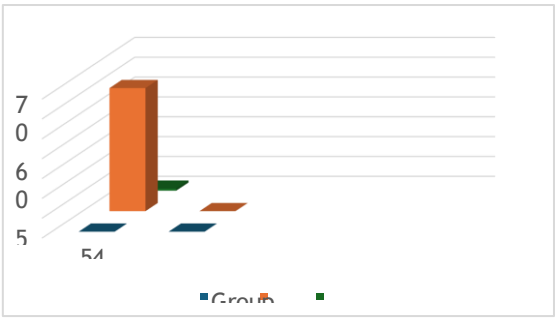


Figure 1. Change in HbA1c (%) after Bariatric Surgery

Diabetes Remission Rates

The rates of diabetes remission after bariatric surgery were significantly higher than those after medical therapy, according to twelve randomized and observational studies. Patients with shorter duration of diabetes and higher baseline insulin sensitivity were more likely to experience remission.

Table 2. Diabetes Remission in 1 Year

Group	Remission Rate (%)	p-value
RYGB	62	<0.001
SG	54	<0.001
Medical Therapy	9	-

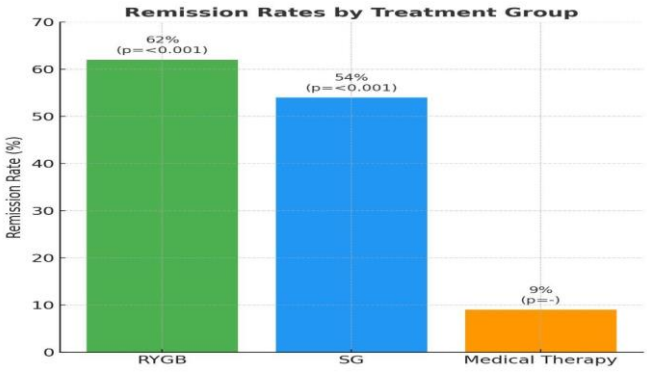


Figure 2. Diabetes Remission in 1 Year

Weight Loss Outcomes

All surgical groups showed significant weight loss, with RYGB resulting in the highest percentage of excess weight loss (EWL). Better metabolic markers were associated with sustained weight loss.

Table 3 – Weight Loss Outcomes

Procedure	% EWL ± SD	p-value
RYGB	68 ± 12	<0.001
SG	61 ± 10	<0.001
AGB	45 ± 15	0.002

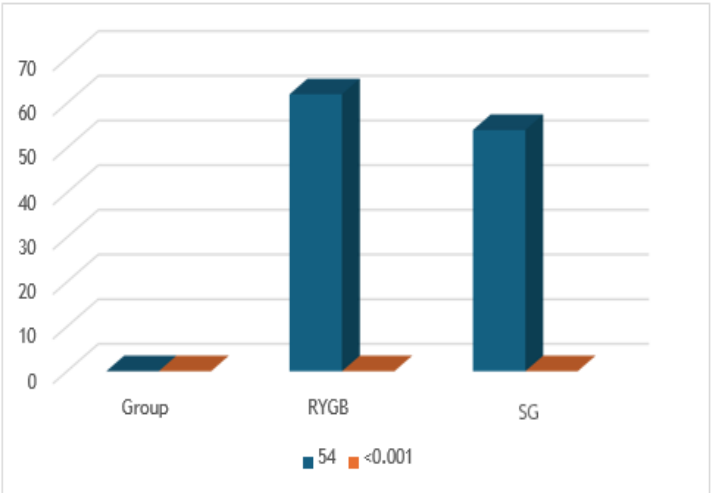


Figure 3 – Weight Loss Outcomes

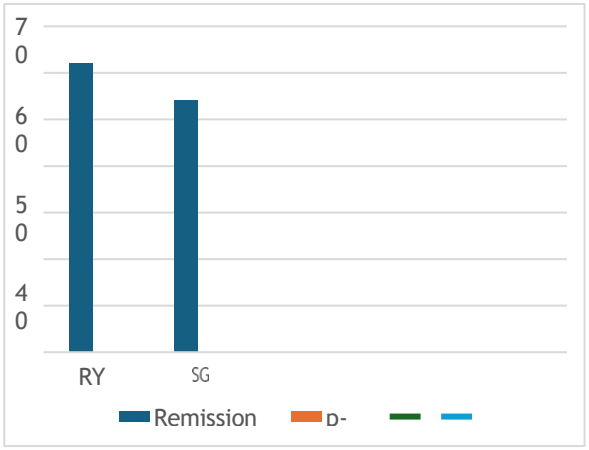
Cardiometabolic Risk Factors

Triglycerides, LDL cholesterol, and blood pressure were among the cardiovascular risk indicators that were considerably lowered by bariatric surgery. The RYGB and SG groups showed the biggest improvements.

Table 4. Change in Cardiometabolic Parameters at 12 Months

Parameter	Baseline	Follow-up	Mean Change	p-value
Systolic BP (mmHg)	142 ± 12	128 ± 10	−14	<0.001
LDL (mg/dL)	128 ± 28	102 ± 22	-26	0.004
Triglycerides (mg/dL)	182 ± 45	136 ± 38	−46	<0.001

Figure 4. Change in Cardiometabolic Parameters at 12 Months



7. DISCUSSION

The results of the literature review confirm that bariatric surgery is a very successful treatment for type 2 diabetes mellitus (T2DM), particularly in obese patients. Roux-en-Y gastric bypass (RYGB) and sleeve gastrectomy (SG) are two surgical procedures that consistently produce better glycemic control and higher rates of diabetes remission when compared to intensive medical therapy alone, according to numerous randomized controlled trials and long-term observational studies [1–3,5–7]. There is compelling evidence from the STAMPEDE trial [3–5] and the Mingrone et al. study [2,6] that metabolic surgery improves patient outcomes by achieving long-lasting decreases in HbA1c and dependence on glucose-lowering drugs.

Bariatric surgery has many ways of working, which is one of its main benefits. Significant weight loss is a major factor in better glucose metabolism and insulin sensitivity, but weight- independent effects are also very important. These include changes in the circulation of bile acids, modifications to the gut microbiome, and changes in gut hormones like GLP-1 and peptide YY, all of which improve β-cell function and glycemic regulation [10,19]. The therapeutic potential of bariatric surgery has increased as a result of our growing understanding of these mechanisms, especially for patients with poorly controlled diabetes but a lower body mass index (BMI) [13,28].

Bariatric surgery has drawbacks even though it works well. Despite being decreased by improvements in surgical methods, the risk of perioperative complications is still a concern, especially for high-risk patient groups [11,21]. In addition, nutritional deficiencies, such as those of calcium, iron, and vitamin B12, require postoperative supplementation and lifelong monitoring [14,17,32].

The varying durability of diabetes remission presents another difficulty; relapse rates rise with extended follow-up and are frequently linked to weight gain and the normal course of type 2 diabetes [9,31,34].

Two important variables affecting results are the choice of patient and the time of surgery. Bariatric surgery is most beneficial for patients with shorter duration of diabetes and preserved pancreatic β-cell function, according to evidence [12,31], underscoring the significance of early intervention in eligible patients. Additionally, although there is still a lack of long-term data in this subgroup, the expansion of bariatric surgery indications to patients with a BMI <35 kg/m² indicates recognition of its metabolic benefits beyond weight reduction [13,28].

By easing the burden of diabetes-related complications and medication dependence, bariatric surgery may lower long-term healthcare costs from a health economics standpoint [15,36]. Its widespread adoption, however, may be constrained by obstacles like insurance coverage, patient willingness to have surgery, and restricted access to specialized surgical centers

[18,30].

To sum up, research backs bariatric surgery as a game-changing strategy for managing type 2 diabetes that has advantages over conventional medical treatments [1,21,34]. A multidisciplinary approach including endocrinologists, surgeons, dietitians, and psychologists is necessary to optimize patient outcomes. To increase the sustainability of diabetes remission, future research should concentrate on improving patient selection, reducing complications, and investigating cutting-edge surgical techniques [19,34,37].

8. CONCLUSION

A complicated metabolic condition, type 2 diabetes mellitus (T2DM) has a significant negative influence on a patient's health and quality of life. Bariatric surgery is a very successful intervention for managing type 2 diabetes, as this systematic review shows, leading to notable improvements in weight loss, insulin sensitivity, and glycemic control. Furthermore, a significant number of patients can experience diabetes remission following bariatric surgery, outperforming results from traditional medical treatments. However, direct comparison between studies is limited by differences in surgical techniques, patient selection, and follow-up times. Although bariatric surgery is becoming more widely acknowledged as a beneficial therapeutic option, issues with perioperative risks, nutritional deficiencies, and the sustainability of remission over the long term still exist. Individualized evaluation and a multidisciplinary strategy that combines surgical intervention with all-encompassing medical and lifestyle support are necessary for improving patient outcomes. To maximize the metabolic advantages of bariatric surgery in the treatment of type 2 diabetes, enhance safety, and improve indications, more research and standardized procedures are needed.

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