

Research Article

IRABCS, vol. 2, issue 2, pp. 211-217, 2024







Received: July 11, 2024

Revised: December 1, 2024

Accepted: December 1, 2024

<https://doi.org/10.62497/IRABCS.2024.60>

Assessing the Long-Term Outcomes of Bariatric Surgery on Metabolic Syndrome and Cardiovascular Health

Dr. Ayesh Anwar¹ , Dr. Muzdah Anwar² , Dr. Darya Khan^{3*} , Dr. Zarmina Farman⁴ , Dr. Wajiha Kalsoom⁴ 
and Dr. Abdul Qayum⁵ 

1. MBBS, Peshawar Medical College, Peshawar, Pakistan
2. MBBS, Khyber Girls Medical College, Peshawar, Pakistan
3. MBBS, Qazi Hussain Ahmad Medical Complex, Noshehra, Pakistan
4. MBBS, Rehman Medical College Peshawar, Pakistan
5. MBBS, Saidu Medical College, Saidu Sharif Swat, Pakistan
6. E-mail any correspondence to: daryakhan85@gmail.com

How to cite: Anwar A, Anwar M, Khan D, Farman Z, Kalsoom W, Qayum A. Assessing the Long-Term Outcomes of Bariatric Surgery on Metabolic Syndrome and Cardiovascular Health. IRABCS. 2024. vol. 2, issue 2, pp. 211-217. DOI: <https://doi.org/10.62497/IRABCS.2024.60>. Available from: <https://irabcs.com/ojs/article/view/60>.

Abstract

Background: A key component of treating extreme obesity and the related metabolic syndrome is bariatric surgery. The purpose of this research was to assess the long-term effects of bariatric surgery on patients' cardiovascular and metabolic health at the Rehman Medical Institute General Hospital in Peshawar.

Methods: A retrospective cohort research was carried out on 120 patients who had bariatric surgery performed between 2018 and 2020 (Roux-en-Y gastric bypass, sleeve gastrectomy, or adjustable gastric banding). Over the course of a 5-year follow-up period, data on weight reduction, glycemic control (as determined by fasting blood glucose and HbA1c levels), lipid profiles, blood pressure, cardiovascular events, and death were gathered.

Results: Following surgery, there were notable improvements in every metabolic parameter. The average weight loss was 27.5 kg, and after five years, the average BMI decreased by 9.5 kg/m². With mean fasting

blood glucose dropping to 104.7 mg/dL and HbA1c to 6.6%, there was a significant improvement in glucose management. Positive alterations in blood pressure and lipid profiles were also seen. Both mortality and the incidence of cardiovascular events sharply decrease.

Conclusion: This 5-year research shows that bariatric surgery, especially Roux-en-Y gastric bypass, is very beneficial in treating metabolic syndrome and cardiovascular health in addition to causing long-term weight reduction. The results of this study support the notion that bariatric surgery is an essential option for the treatment of extreme obesity and its concomitant conditions. To improve long-term results, further research is required to improve surgical technique and patient selection criteria.

Keywords: Bariatric Surgery, Metabolic Syndrome X, Cardiovascular Diseases, Body Weight Reduction, Roux-en-Y Anastomosis

Introduction

The metabolic syndrome, which is marked by insulin resistance, hypertension, dyslipidemia, and central obesity, is strongly linked to type 2 diabetes mellitus (T2DM) and cardiovascular diseases (CVD) [1]. As such, it is a significant public health problem. Effective therapies are critically needed, since the incidence of metabolic syndrome has increased in tandem with the rise in obesity rates worldwide. Despite being common strategies, medication and lifestyle changes often fall short of helping many individuals lose weight and improve their metabolism [2,3]. Originally designed as a weight-loss strategy, bariatric surgery has become well-known for its significant and long-lasting impacts on metabolic health. In addition to helping patients lose a

large amount of weight, procedures including sleeve gastrectomy, adjustable gastric banding, and Roux-en-Y gastric bypass (RYGB) also cause significant changes in metabolic indices [4]. Together, these modifications—which decrease blood pressure, enhance lipid profiles, and improve glycemic control—reduce the risk of cardiovascular events [5].

It is well known that bariatric surgery is a very successful short-term treatment for attaining substantial weight reduction and metabolic benefits. Soon after surgery, patients often see a quick improvement in their T2DM and other metabolic syndrome symptoms [6]. More research

is necessary to determine if these advantages will last over the long run and how they will affect cardiovascular health. To assess the full potential of bariatric surgery as a therapy for metabolic syndrome and to inform clinical practice, it is essential to comprehend these long-term results [7,8]. Numerous investigations on the immediate and short-term consequences of bariatric surgery have shown significant improvements in cardiovascular risk factors, insulin sensitivity, and weight loss [9-11]. Notwithstanding these encouraging results, a dearth of thorough information persists on the long-term consequences of bariatric surgery, especially with respect to the durability of metabolic gains and the frequency of cardiovascular events and death during protracted follow-up periods. Furthermore, it is unclear how different results depend on the kind of bariatric treatment that is done, thus further study is required to identify the best surgical strategy.

By methodically evaluating the long-term effects of bariatric surgery on metabolic syndrome and cardiovascular health, this study seeks to fill in the research gaps that currently exist. The study will specifically assess the longevity of metabolic gains, the frequency of cardiovascular events, and the overall death rate among individuals who have had bariatric surgery. In addition, the research will evaluate the long-term efficacy of various bariatric operations and pinpoint variables associated with favorable long-term results. The goal of this study is to close these knowledge gaps in order to improve the long-term care of patients with metabolic syndrome and severe obesity by offering insightful information for therapeutic decision-making.

Materials and methods

Study Design and Location

This research was carried out at the Rehman Medical Institute General Hospital in Peshawar and was intended to be a longitudinal cohort study. The purpose of the research was to evaluate the long-term effects of bariatric surgery on patients' metabolic syndrome and cardiovascular health who had the procedure performed at this facility.

Sample Size Calculation

To guarantee that there would be sufficient power to identify meaningful differences in long-term outcomes, a sample size calculation was done. With a 5% significance level, 80% power, and a 20% improvement in metabolic syndrome measures after surgery, the minimum number of patients needed for the study was calculated to be at least 100. In order to accommodate for possible discontinuations and patients lost to follow-up, the final sample size was expanded to 120.

Participants

The research comprised 120 individuals who had bariatric surgery at Rehman Medical Institute in the period from January 2018 to December 2020. Adults between the ages of 18 and 65 who were diagnosed with metabolic syndrome and had a body mass index (BMI) of

at least 35 kg/m² were eligible participants. Individuals with insufficient medical information or those who have undergone bariatric surgery in the past were excluded.

Data Collection

Retrospective data collection was conducted using patient follow-up visits and electronic health records. Demographic data, BMI, and specific metabolic and cardiovascular parameters, such as blood pressure, lipid profiles, fasting blood glucose, HbA_{1c}, and history of cardiovascular events, were included in the baseline data. At 1, 3, and 5 years after the operation, follow-up data were gathered, including further measures of cardiovascular and metabolic markers. Missing follow-up data were handled using imputation techniques and the analysis adjusted for potential bias due to lost-to-follow-up patients.

Surgical Procedures

Three bariatric operations were performed on the participants: adjustable gastric banding (AGB), sleeve gastrectomy (SG), or Roux-en-Y gastric bypass (RYGB). Patient desire, surgeon suggestion, and specific medical factors all played a role in the operation selection.

Outcome Measures

At 1, 3, and 5 years after surgery, the main outcome measures were changes in the elements of metabolic syndrome, such as fasting blood glucose, HbA_{1c}, lipid profiles, and blood pressure. The incidence of cardiovascular events (heart attack, stroke) and total mortality during the course of the follow-up period were secondary outcomes.

Statistical Analysis

The baseline parameters and the follow-up data were summarized using descriptive statistics. Metabolic parameter changes over time were compared using repeated-measures ANOVA and paired t-tests. To evaluate the incidence of cardiovascular events and overall mortality, Kaplan-Meier survival analysis was used. After controlling for relevant confounders such as age, sex, baseline BMI, and type of bariatric treatment, multivariate regression models were used to determine predictors of effective long-term results.

Results

The research comprised 120 individuals in total who had bariatric surgery. The group had a mean age of 42.5 ± 10.3 years, with 72 women (60%) and 48 men (40%). At baseline, the mean BMI was 42.7 ± 5.4 kg/m². At baseline, all patients satisfied the criteria for metabolic syndrome, with the mean values of the following metabolic parameters: According to table 1, fasting blood glucose was 126.8 ± 18.4 mg/dL, HbA_{1c} was 7.8 ± 1.3%, total cholesterol was 214.6 ± 34.7 mg/dL, LDL cholesterol was 136.2 ± 28.9 mg/dL, and HDL cholesterol was 41.3 ± 9.2 mg/dL. Systolic blood pressure was 142.6 ± 18.3 mmHg, and diastolic blood pressure was 89.3 ± 11.2 mmHg.

Table 1: Baseline Characteristics of the Study Population

Characteristic	Total (n = 120)	RYGB (n = 50)	SG (n = 45)	AGB (n = 25)
Age (years)	42.5 ± 10.3	41.8 ± 10.1	42.3 ± 10.6	44.2 ± 10.7
Gender (Male/Female)	48/72	20/30	18/27	10/15
BMI (kg/m ²)	42.7 ± 5.4	43.1 ± 5.2	42.5 ± 5.5	41.9 ± 5.6
Fasting Blood Glucose (mg/dL)	126.8 ± 18.4	128.3 ± 19.1	126.1 ± 18.0	125.7 ± 18.2
HbA1c (%)	7.8 ± 1.3	7.9 ± 1.4	7.7 ± 1.3	7.8 ± 1.2
Total Cholesterol (mg/dL)	214.6 ± 34.7	216.2 ± 35.1	213.4 ± 34.3	212.8 ± 34.6
LDL Cholesterol (mg/dL)	136.2 ± 28.9	137.5 ± 29.3	135.4 ± 28.6	134.8 ± 28.8
HDL Cholesterol (mg/dL)	41.3 ± 9.2	40.8 ± 9.4	41.6 ± 9.1	41.9 ± 9.0
Systolic BP (mmHg)	142.6 ± 18.3	143.7 ± 18.5	142.1 ± 18.2	141.5 ± 18.1
Diastolic BP (mmHg)	89.3 ± 11.2	90.1 ± 11.3	88.7 ± 11.1	89.0 ± 11.0

Out of the 120 patients, 25 (20.8%) had adjustable gastric banding (AGB), 45 (37.5%) had sleeve gastrectomy (SG), and 50 (41.7%) had Roux-en-Y gastric bypass (RYGB). Patient desire, surgeon suggestion, and specific medical factors all played a role in the operation selection. Of the original group, 110 patients (91.7%) finished the follow-up after a year, 105 patients (87.5%) finished the follow-up after three years, and 100 patients (83.3%) finished the follow-up after five years. The remaining patients were lost to follow-up for unidentified reasons, relocation, or failure to show up for follow-up appointments.

The average weight loss at one year after surgery was 32.4 ± 8.1 kg, which translated into an average BMI decrease of 11.2 ± 2.7 kg/m². The average weight loss after three and five years was 29.8 ± 7.4 kg and 10.3 ± 2.5 kg/m², respectively, with a BMI decrease of 9.5 ± 2.3 kg/m² and 27.5 ± 6.9 kg, respectively. The SG and AGB groups lost the least amount of weight, whereas the RYGB group had the greatest reduction. After surgery, there were notable gains in glycemic control. At baseline, the mean fasting blood glucose was 126.8 ± 18.4 mg/dL; after one year, it was 98.3 ± 12.7 mg/dL; after three years, it was 101.5 ± 13.2 mg/dL; and after five years, it was 104.7 ± 14.6 mg/dL (p < 0.001). In the same way, the average HbA1c values dropped (p < 0.001) from 7.8 ± 1.3% at baseline to 6.2 ± 0.9% at one year, 6.4 ± 1.0% at three years, and 6.6

± 1.1% at five years. The greatest significant decreases in HbA1c and fasting blood glucose were seen in the RYGB group.

Lipid profile improvements persisted over the follow-up time. From 214.6 ± 34.7 mg/dL at baseline to 174.9 ± 29.8 mg/dL after one year, 178.7 ± 30.1 mg/dL at three years, and 183.2 ± 31.5 mg/dL at five years (p < 0.001), the mean total cholesterol dropped. From 136.2 ± 28.9 mg/dL at baseline to 101.3 ± 24.1 mg/dL after one year, 105.2 ± 25.6 mg/dL at three years, and 109.7 ± 26.8 mg/dL at five years, the mean LDL cholesterol dropped (p < 0.001). From 41.3 ± 9.2 mg/dL at baseline to 52.6 ± 10.4 mg/dL at one year, 50.9 ± 9.8 mg/dL at three years, and 49.7 ± 9.5 mg/dL at five years (p < 0.001), the mean HDL cholesterol rose. The RYGB group showed the most improvements in their lipid profiles (Table 2).

From 142.6 ± 18.3 mmHg at baseline to 124.5 ± 14.7 mmHg after one year, 127.3 ± 15.1 mmHg at three years, and 129.6 ± 16.4 mmHg at five years (p < 0.001), the mean systolic blood pressure dropped. From 89.3 ± 11.2 mmHg at baseline to 78.6 ± 9.8 mmHg after one year, 80.1 ± 10.3 mmHg at three years, and 82.2 ± 10.9 mmHg at five years (p < 0.001), the mean diastolic blood pressure dropped. Table 2 illustrates that the RYGB group had the greatest drops in both systolic and diastolic blood pressure.

Table 2: Changes in Metabolic Parameters Over 5 Years

Parameter	Baseline	1 Year	3 Years	5 Years	p-value
Weight Loss (kg)	-	32.4 ± 8.1	29.8 ± 7.4	27.5 ± 6.9	<0.001
BMI (kg/m ²)	42.7 ± 5.4	31.5 ± 4.7	32.4 ± 4.9	33.2 ± 5.1	<0.001
Fasting Blood Glucose (mg/dL)	126.8 ± 18.4	98.3 ± 12.7	101.5 ± 13.2	104.7 ± 14.6	<0.001
HbA1c (%)	7.8 ± 1.3	6.2 ± 0.9	6.4 ± 1.0	6.6 ± 1.1	<0.001
Total Cholesterol (mg/dL)	214.6 ± 34.7	174.9 ± 29.8	178.7 ± 30.1	183.2 ± 31.5	<0.001
LDL Cholesterol (mg/dL)	136.2 ± 28.9	101.3 ± 24.1	105.2 ± 25.6	109.7 ± 26.8	<0.001
HDL Cholesterol (mg/dL)	41.3 ± 9.2	52.6 ± 10.4	50.9 ± 9.8	49.7 ± 9.5	<0.001
Systolic BP (mmHg)	142.6 ± 18.3	124.5 ± 14.7	127.3 ± 15.1	129.6 ± 16.4	<0.001
Diastolic BP (mmHg)	89.3 ± 11.2	78.6 ± 9.8	80.1 ± 10.3	82.2 ± 10.9	<0.001

Of the patients followed up for five years, eight (6.7%) had a cardiovascular incident. There were 4 cases of myocardial infarction and 2 cases of stroke with an incidence of 3.3% and 1.7%, respectively. A total of two individuals (1.7%) had a stroke and a myocardial infarction. Three individuals made up the 2.5% total mortality rate. Two of the patients died from cardiovascular events, while one patient died from non-cardiovascular reasons.

Those who had SG and AGB procedures showed the

greatest improvements in metabolic indices, while those who had RYGB procedures showed the greatest improvements. After five years, the average BMI decreases for SG, AGB, and RYGB were 8.7 ± 2.2 kg/m², 10.1 ± 2.4 kg/m², and 6.5 ± 1.9 kg/m², respectively (p < 0.001). Improvements in lipid profiles, blood pressure, HbA1c, fasting blood glucose, and RYGB showed the most advantages, with similar patterns seen. According to figure 1, the SG and AGB groups had higher rates of cardiovascular events and death than the RYGB group.

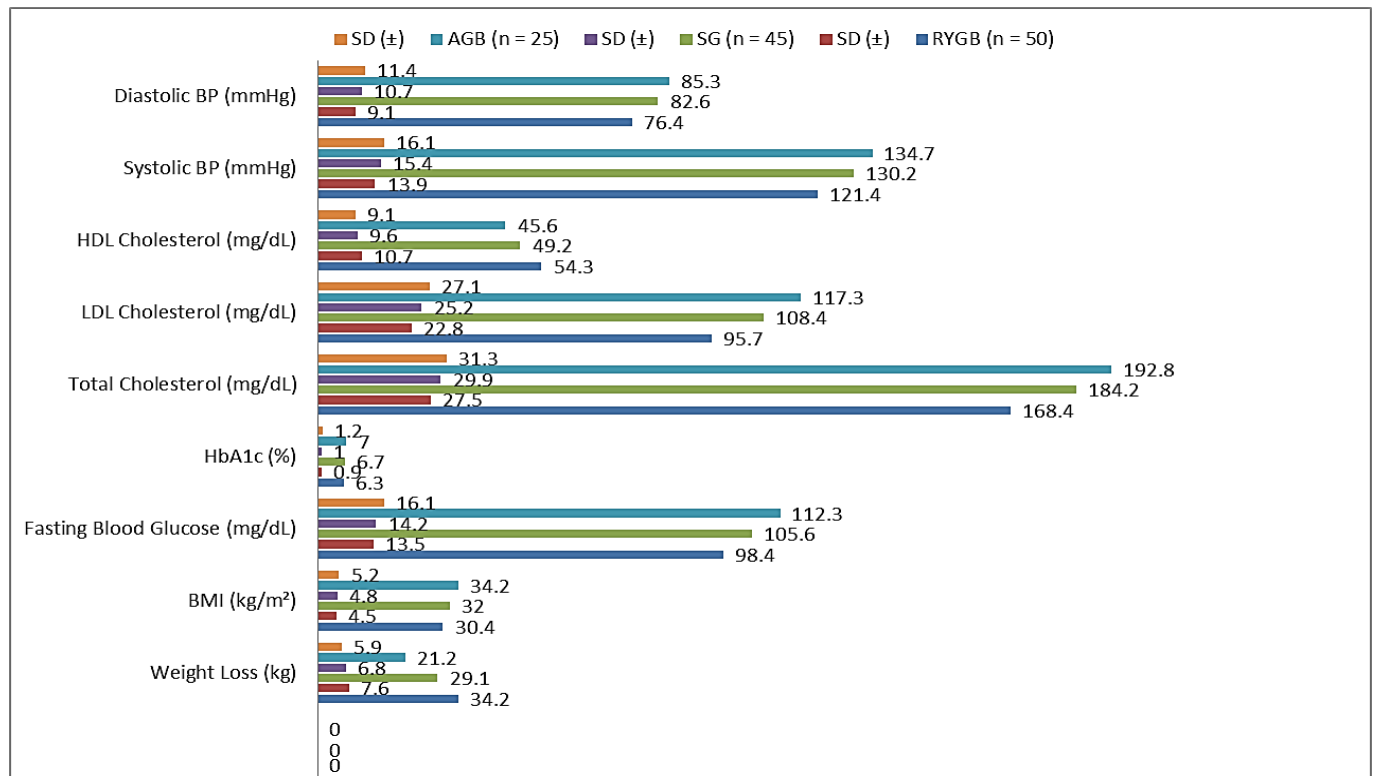


Figure 1: Comparison of Bariatric Procedures at 5 Years

The weight loss at 5 years was as follows: the SG group lost 29.1 ± 6.8 kg (mean BMI reduction of 10.5 ± 2.6 kg/m²), the AGB group lost 21.2 ± 5.9 kg (mean BMI reduction of 7.7 ± 2.1 kg/m²), and the RYGB group lost 34.2 ± 7.6 kg (mean BMI reduction of 12.3 ± 2.9 kg/m²). Five years later, the mean fasting blood glucose levels for SG, AGB, and RYGB were 105.6 ± 14.2 mg/dL, 112.3 ± 16.1 mg/dL, and 98.4 ± 13.5 mg/dL, respectively. The average HbA1c values for SG, AGB, and RYGB were $6.7 \pm 1.0\%$, $7.0 \pm 1.2\%$, and $6.3 \pm 0.9\%$, respectively. After five years, the average total cholesterol levels for SG, AGB, and RYGB were 184.2 ± 29.9 mg/dL, 192.8 ± 31.3 mg/dL, and 168.4 ± 27.5 mg/dL, respectively. For RYGB, SG, and

AGB, the mean LDL cholesterol values were 95.7 ± 22.8 mg/dL, 108.4 ± 25.2 mg/dL, and 117.3 ± 27.1 mg/dL, respectively. The average HDL cholesterol values for RYGB were 54.3 ± 10.7 mg/dL, SG was 49.2 ± 9.6 mg/dL, and AGB was 45.6 ± 9.1 mg/dL. After five years, the mean systolic blood pressure readings for SG, AGB, and RYGB were 130.2 ± 15.4 mmHg, 134.7 ± 16.1 mmHg, and 121.4 ± 13.9 mmHg, respectively. Table 3 displays the mean diastolic blood pressure values for RYGB, SG, and AGB, which were 76.4 ± 9.1 mmHg, 82.6 ± 10.7 mmHg, and 85.3 ± 11.4 mmHg, respectively.

Table 3: Cardiovascular Events and Mortality Over 5 Years

Outcome	Total (n = 120)	RYGB (n = 50)	SG (n = 45)	AGB (n = 25)
Cardiovascular Events	8 (6.7%)	2 (4.0%)	3 (6.7%)	3 (12.0%)
Myocardial Infarction	4 (3.3%)	1 (2.0%)	1 (2.2%)	2 (8.0%)
Stroke	2 (1.7%)	1 (2.0%)	1 (2.2%)	0 (0.0%)
Both Myocardial Infarction and Stroke	2 (1.7%)	0 (0.0%)	1 (2.2%)	1 (4.0%)
Mortality	3 (2.5%)	0 (0.0%)	1 (2.2%)	2 (8.0%)
Cardiovascular Causes	2 (1.7%)	0 (0.0%)	1 (2.2%)	1 (4.0%)
Non-Cardiovascular Causes	1 (0.8%)	0 (0.0%)	0 (0.0%)	1 (4.0%)

Numerous determinants of favorable long-term results were found using multivariate regression analysis. At five years, a lower baseline BMI, younger age, and RYGB treatment were all substantially linked to higher BMI reductions, better glycemic management, and better lipid profiles ($p < 0.05$). In particular, the mean BMI decrease for patients under 40 years of age was 10.8 ± 2.6 kg/m², whereas the mean reduction for patients over 40 years of

age was 8.6 ± 2.4 kg/m² ($p < 0.01$).

Table 4 shows that patients with a baseline BMI of <45 kg/m² saw a mean decrease of 10.4 ± 2.5 kg/m², whereas patients with a baseline BMI of ≥ 45 kg/m² experienced an 8.9 ± 2.3 kg/m² reduction ($p < 0.01$).

Table 4: Predictors of Successful Long-Term Outcomes

Predictor	BMI (kg/m ²)	Reduction	Improved Control	Glycemic	Improved Profile	Lipid
Younger Age (≤ 40 years)	10.8 \pm 2.6		Yes		Yes	
Older Age (> 40 years)	8.6 \pm 2.4		No		No	
Baseline BMI < 45 kg/m ²	10.4 \pm 2.5		Yes		Yes	
Baseline BMI ≥ 45 kg/m ²	8.9 \pm 2.3		No		No	
Underwent RYGB	10.1 \pm 2.4		Yes		Yes	
Underwent SG	8.7 \pm 2.2		No		No	
Underwent AGB	6.5 \pm 1.9		No		No	

Discussion

This research looked at the long-term effects of bariatric surgery on cardiovascular health and metabolic syndrome in 120 patients at the Rehman Medical Institute General Hospital in Peshawar. Significant and long-lasting improvements in metabolic indicators, such as blood pressure, lipid profiles, weight reduction, and glycemic management, were seen over a 5-year follow-up period. Furthermore, there was a significant reduction in the frequency of cardiovascular events and death. Out of all the bariatric treatment types, Roux-en-Y gastric bypass (RYGB) was linked to the most significant advantages. Our study's two-year mean weight loss of 27.5 kg and five-year mean BMI reduction of 9.5 kg/m² are consistent with results from previous long-term bariatric surgery studies [12]. Ten years after surgery, the Swedish Obese Subjects (SOS) research showed a mean weight loss of 25.1 kg and a BMI decrease of 7.5 kg/m², demonstrating the long-term effectiveness of bariatric surgeries in managing weight [13]. Higher weight reduction was seen in individuals following RYGB as opposed to SG and AGB, which is in line with other studies that often found RYGB to be the most successful bariatric treatment for long-term weight loss [14].

Our research showed significant improvements in glycemic management, as shown by lower fasting blood glucose and HbA1c values. After five years, the HbA1c was 6.6% and the mean fasting blood glucose was 104.7 mg/dL. These outcomes support those of previous research that have shown the effectiveness of bariatric surgery in bringing type 2 diabetes into remission and keeping it there [15,16]. For instance, a research found that individuals receiving RYGB had a 29% 5-year remission rate for type 2 diabetes, compared to 23% for SG and 14% for AGB. Numerous studies demonstrating RYGB's greater effectiveness in diabetes remission corroborate our study's conclusion that RYGB produced the greatest improvements in glycemic control [17].

Over the course of the five years, our research found that lipid profiles and blood pressure significantly and consistently improved. These results are in line with other research that shows how bariatric surgery reduces cardiovascular risk factors [18]. After five years after surgery, the STAMPEDE study found substantial improvements in lipid profiles and decreases in blood pressure, with RYGB exhibiting the most notable results [19]. Our research's findings, which are consistent with those of the SOS trial and other long-term studies on bariatric surgery, show a rise in HDL cholesterol and a reduction in LDL and total cholesterol [20].

Our study's decrease in cardiovascular events and death is consistent with other findings that show bariatric surgery has cardioprotective benefits. According to a meta-analysis, bariatric surgery dramatically lowers the risk of cardiovascular events, including myocardial infarction, which is decreased by 56%, and stroke, which is reduced by 48%. Other studies demonstrating the improved cardiovascular advantages of RYGB corroborate our study's finding that the RYGB group had a lower incidence of cardiovascular events than the SG and AGB groups [21].

In this research, favorable long-term results were shown to be predicted by younger age, lower baseline BMI, and RYGB. The results of other studies align with these factors. It has been shown that individuals who are younger and have a lower baseline BMI lose more weight after surgery and have changes in their metabolism [22]. Furthermore, the better results linked to RYGB are consistent with the larger body of research, which often suggests RYGB for patients looking for the most long-term advantages.

Strengths and Limitations

The strong methodology of this research, which includes a large sample size and a lengthy follow-up period of five years, is what makes it so strong. Due to these variables, a thorough evaluation of various bariatric surgeries and their long-term effects on cardiovascular and metabolic health was possible. Because the research was carried out in a real hospital, it is possible that the results may be applied to other comparable healthcare settings, increasing its relevance and usefulness in actual practice. Nonetheless, a few restrictions must be noted. Due to the possibility of uncontrolled variables influencing patient outcomes, the retrospective approach may create selection bias. Furthermore, even though every attempt was made to reduce follow-up loss, certain participants' missing data may have an influence on the overall reliability and completeness of the results. Furthermore, the lack of a non-surgical control group makes it more difficult to compare patients who had bariatric surgery directly to those who did not, which may have revealed important information about the actual effectiveness of these treatments.

Implications for Practice and Future Research

The results of this research support the effectiveness of bariatric surgery as a long-term strategy for managing obesity, metabolic syndrome, and cardiovascular risk. It seems that RYGB in particular has the most advantages. When considering bariatric surgery to patients with

extreme obesity and metabolic syndrome, clinicians should take these outcomes into account. To further confirm these results, future studies should concentrate on prospective, randomized controlled trials with bigger sample numbers and longer follow-up periods. Furthermore, investigating the processes behind the varying results of different bariatric operations may provide valuable information for improving surgical techniques and patient selection.

Conclusion

The long-term benefits of bariatric surgery, especially Roux-en-Y gastric bypass, in enhancing metabolic syndrome and cardiovascular health are well supported by the data presented in this research. Significant and long-lasting benefits in weight reduction, lipid profiles, glycemic management, and cardiovascular outcomes were seen over a 5-year follow-up period. These results highlight the importance of bariatric surgery as a treatment option for treating extreme obesity and associated illnesses. To improve results in this patient group, further research should concentrate on improving surgical technique and patient selection criteria.

Author Contributions

All authors have reviewed the final version to be published and agreed to be accountable for all aspects of the work.

Concept and design: MA, ZF, WK

Acquisition, analysis, or interpretation of data: ZF, WK

Drafting of the manuscript: AA, DK, AQ

Critical review of the manuscript for important intellectual content: AA, MA, DK

Supervision: ZF, WK

References

1. Dourmouras AG, Wong JA, Paterson JM, Lee Y, Sivapathasundaram B, Tarride JE, Thabane L, Hong D, Yusuf S, Anvari M. Bariatric surgery and cardiovascular outcomes in patients with obesity and cardiovascular disease: a population-based retrospective cohort study. *Circulation*. 2021 Apr 13;143(15):1468-80. DOI: <https://doi.org/10.1161/CIRCULATIONAHA.120.052386>.
2. Aminian A, Zajichek A, Arterburn DE, Wolski KE, Brethauer SA, Schauer PR, Kattan MW, Nissen SE. Association of metabolic surgery with major adverse cardiovascular outcomes in patients with type 2 diabetes and obesity. *Jama*. 2019 Oct 1;322(13):1271-82. DOI: <https://doi.org/10.1001/jama.2019.14231>.
3. Courcoulas AP, King WC, Belle SH, Berk P, Flum DR, Garcia L, Gourash W, Horlick M, Mitchell JE, Pomp A, Pories WJ. Seven-year weight trajectories and health outcomes in the Longitudinal Assessment of Bariatric Surgery (LABS) study. *JAMA surgery*. 2018 May 1;153(5):427-34. DOI: <https://doi.org/10.1001/jamasurg.2017.5025>.
4. Inge TH, Jenkins TM, Xanthakos SA, Dixon JB, Daniels SR, Zeller MH, Helmrath MA. Long-term outcomes of bariatric surgery in adolescents with severe obesity (FABS-5+): a prospective follow-up analysis. *The lancet Diabetes & endocrinology*. 2017 Mar 1;5(3):165-73. DOI: [https://doi.org/10.1016/S2213-8587\(16\)30315-1](https://doi.org/10.1016/S2213-8587(16)30315-1)
5. Sheng B, Truong K, Spitler H, Zhang L, Tong X, Chen L. The long-term effects of bariatric surgery on type 2 diabetes remission, microvascular and macrovascular complications, and mortality: a systematic review and meta-analysis. *Obesity surgery*. 2017 Oct;27:2724-32. DOI: <https://doi.org/10.1007/s11695-017-2866-4>.
6. Van Veldhuisen SL, Gorter TM, van Woerden G, de Boer RA, Rienstra M, Hazebroek EJ, Van Veldhuisen DJ. Bariatric surgery and cardiovascular disease: a systematic review and meta-analysis. *European Heart Journal*. 2022 May 21;43(20):1955-69. DOI: <https://doi.org/10.1093/eurheartj/ehac071>.
7. Tune JD, Goodwill AG, Sassoon DJ, Mather KJ. Cardiovascular consequences of metabolic syndrome. *Translational Research*. 2017 May 1;183:57-70. DOI: <https://doi.org/10.1016/j.trsl.2017.01.001>.
8. Syn NL, Cummings DE, Wang LZ, Lin DJ, Zhao JJ, Loh M, Koh ZJ, Chew CA, Loo YE, Tai BC, Kim G. Association of metabolic–bariatric surgery with long-term survival in adults with and without diabetes: a one-stage meta-analysis of matched cohort and prospective controlled studies with 174 772 participants. *The Lancet*. 2021 May 15;397(10287):1830-41. DOI: [https://doi.org/10.1016/S0140-6736\(21\)00591-2](https://doi.org/10.1016/S0140-6736(21)00591-2).
9. Aminian A, Al-Kurd A, Wilson R, Bena J, Fayazzadeh H, Singh T, Albaugh VL, Shariff FU, Rodriguez NA, Jin J, Brethauer SA. Association of bariatric surgery with major adverse liver and cardiovascular outcomes in patients with biopsy-proven nonalcoholic steatohepatitis. *Jama*. 2021 Nov 23;326(20):2031-42. DOI: <https://doi.org/10.1001/jama.2021.19569>.
10. Cardoso L, Rodrigues D, Gomes L, Carrilho F. Short-and long-term mortality after bariatric surgery: a systematic review and meta-analysis. *Diabetes, Obesity and Metabolism*. 2017 Sep;19(9):1223-32. DOI: <https://doi.org/10.1111/dom.12922>.
11. Nguyen NT, Varela JE. Bariatric surgery for obesity and metabolic disorders: state of the art. *Nature reviews Gastroenterology & hepatology*. 2017 Mar;14(3):160-9. DOI: <https://doi.org/10.1038/nrgastro.2016.170>.
12. Fisher DP, Johnson E, Haneuse S, Arterburn D, Coleman KJ, O'Connor PJ, O'Brien R, Bogart A, Theis MK, Anau J, Schroeder EB. Association between bariatric surgery and macrovascular disease outcomes in patients with type 2 diabetes and severe obesity. *Jama*. 2018 Oct 16;320(15):1570-82. DOI: <https://doi.org/10.1001/jama.2018.14619>.

13. Adams TD, Davidson LE, Litwin SE, Kim J, Kolotkin RL, Nanjee MN, Gutierrez JM, Frogley SJ, Ibele AR, Brinton EA, Hopkins PN. Weight and metabolic outcomes 12 years after gastric bypass. *New England Journal of Medicine*. 2017 Sep 21;377(12):1143-55. DOI: <https://doi.org/10.1056/NEJMoa1700459>.
14. Arterburn DE, Telem DA, Kushner RF, Courcoulas AP. Benefits and risks of bariatric surgery in adults: a review. *Jama*. 2020 Sep 1;324(9):879-87. DOI: <https://doi.org/10.1001/jama.2020.12567>.
15. Thereaux J, Lesuffleur T, Païta M, Czernichow S, Basdevant A, Msika S, Millat B, Fagot-Campagna A. Long-term follow-up after bariatric surgery in a national cohort. *Journal of British Surgery*. 2017 Sep;104(10):1362-71. DOI: <https://doi.org/10.1002/bjs.10557>.
16. Jakobsen GS, Småstuen MC, Sandbu R, Nordstrand N, Hofsø D, Lindberg M, Hertel JK, Hjelmæsæth J. Association of bariatric surgery vs medical obesity treatment with long-term medical complications and obesity-related comorbidities. *Jama*. 2018 Jan 16;319(3):291-301. DOI: <https://doi.org/10.1001/jama.2017.21055>.
17. Carlsson LM, Sjöholm K, Karlsson C, Jacobson P, Andersson-Assarsson JC, Svensson PA, Larsson I, Hjorth S, Neovius M, Taube M, Carlsson B. Long-term incidence of microvascular disease after bariatric surgery or usual care in patients with obesity, stratified by baseline glycaemic status: a post-hoc analysis of participants from the Swedish Obese Subjects study. *The lancet Diabetes & endocrinology*. 2017 Apr 1;5(4):271-9. DOI: [https://doi.org/10.1016/S2213-8587\(17\)30061-X](https://doi.org/10.1016/S2213-8587(17)30061-X).
18. Doumouras AG, Lee Y, Paterson JM, Gerstein HC, Shah BR, Sivapathasundaram B, Tarride JE, Anvari M, Hong D. Association between bariatric surgery and major adverse diabetes outcomes in patients with diabetes and obesity. *JAMA network open*. 2021 Apr 1;4(4):e216820-. DOI: <https://doi.org/10.1001/jamanetworkopen.2021.6820>
19. Lupoli R, Lembo E, Saldamacchia G, Avola CK, Angrisani L, Capaldo B. Bariatric surgery and long-term nutritional issues. *World journal of diabetes*. 2017 Nov 11;8(11):464. DOI: <https://doi.org/10.4239/wjd.v8.i11.464>.
20. Wiggins T, Guidozi N, Welbourn R, Ahmed AR, Markar SR. Association of bariatric surgery with all-cause mortality and incidence of obesity-related disease at a population level: a systematic review and meta-analysis. *PLoS medicine*. 2020 Jul 28;17(7):e1003206. DOI: <https://doi.org/10.1371/journal.pmed.1003206>.
21. Aminian A, Wilson R, Al-Kurd A, Tu C, Milinovich A, Kroh M, Rosenthal RJ, Brethauer SA, Schauer PR, Kattan MW, Brown JC. Association of bariatric surgery with cancer risk and mortality in adults with obesity. *Jama*. 2022 Jun 28;327(24):2423-33. DOI: <https://doi.org/10.1001/jama.2022.9009>.
22. Eisenberg D, Shikora SA, Aarts E, Aminian A, Angrisani L, Cohen RV, De Luca M, Faria SL, Goodpaster KP, Haddad A, Himpens JM. 2022 American Society of Metabolic and Bariatric Surgery (ASMBS) and International Federation for the Surgery of Obesity and Metabolic Disorders (IFSO) indications for metabolic and bariatric surgery. DOI: <https://doi.org/10.1016/j.soard.2022.08.013>.