Original Article

# Effect of Bariatric Surgeries on Cardiovascular Risk Factors: Single Institution Retrospective Study

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**Abstract**

**Background:**
Recently bariatric surgeries became trend for obese individuals. As known obesity is major risk factor for cardiovascular diseases. We Aim to describe effect of bariatric surgeries on cardiovascular risk factors including glycemic control, lipid profile, blood pressure, and weight for patients registered at tertiary center in Saudi Arabia.

**Methods:**
Retrospective cohort including obese patients who underwent bariatric surgeries at King Abdullah Medical City, Makkah between 2013 and February 2016.

**Results:**
Total of 566 patients aged 34.8±10.2 years at time of operation. More than half were females (58.1%). Almost all patients underwent laparoscopic sleeve gastrectomy (95.9%). Diabetes and hypertension were the most prevalent comorbidities (24.8% and 18.9%, respectively). There is significant reduction in mean Body Mass Index from 47.6 kg/m2 to 31.8 kg/m2 and in Glycosylated Hemoglobin from 6.8% to 5.7% At 24 months of follow-up ($p<0.001$ for both parameters). Baseline High Density Lipoprotein (44.4 mg/dl), non-HDL cholesterol (147.1 mg/dl) and triglyceride (123.6 mg/dl) improved significantly to reach 52.3 mg/dl, 137.7 mg/dl and 78.5 mg/dl, respectively at one-year post-operative follow-up. Out of 79 hypertensive patients, 57 patients had remission of hypertension in last follow-up ($p<0.001$). Among diabetic patients,

**المخلص**

**الخلفية :**
في الآونة الأخيرة تشهد عمليات السمنة انتشاراً واسعاً بين كافة طبقات المجتمع عامةً ومرضى السمنةِ خاصةً. وتتعدد الدوافع للجوء إلا ان الغالب هو العلاجية منها؛ حيث تعد السمنةُ عامل خطرٍ للإصابةِ بأمراض القلبِ والأوعيةِ الدموية.
تهدف هذه الدراسة لوصف واستقصاء تأثير عمليات السمنة على مختلف عوامل الخطورة المؤدية للإصابة بأمراض القلبِ والأوعيةِ الدمويةِ كالوزن، نسبة سكر الدم، نسبة دهون الدم وضغط الدم بين مرضى السمنة المسجلين في أحد مراكز المملكة العربية السعودية المرجعية.

**طريقة البحث :**
تعد هذه الدراسة دراسة استعادية وتشمل جميع مرضى السمنة المسجلين في مدينة الملك عبد الله الطبية بمنطقة مكة المكرمة والذين قاموا بإجراء أحد عمليات السمنة خلال المدة الزمنية ما بين بداية السنة الميلادية لعام ٢٠١٣ ولغاية شهر فبراير من السنة الميلادية ٢٠١٦.

**النتائج:**
شملت العينة البحثية ٥٦٦ مريضاً بلغ متوسط أعمارهم ٣٤,٨ ± ١٠,٢ سنة، غالبيتهم من النساء بنسبة ٥٨,١٪. وأظهرت نتائج الدراسة أن النوع الأكثر انتشاراً لعمليات السمنة بين المرضى هي عملية تكميم المعدة الطولي بالمنظار الجراحي بنسبة ٩٥,٩٪. قُدِرَت نسب مرض السكري ومرض ارتفاع ضغط الدم كأكثر الأمراض انتشارا بين هؤلاء المرضى بنسبة ٢٤,٨٪ و١٨,٩٪، على التوالي. أفادت الدراسة بوجود انخفاض ملحوظ بعد سنتان منذ وقت العملية الجراحية في متوسط كتلة الجسم من ٤٧,٦ كجم/م٢ إلى ١٨,٩ كجم/م٢ ومعدل سكر الدم التراكمي من ٦,٨٪ إلى ٥,٧٪. من جانب أخر أثبتت الدراسة وجود تحسن في نسب كلاً من: الدهون البروتينية عالية الكثافة من ٤٤,٤ ملجم/ديسيلتر إلى ٥٢,٣ ملجم/ديسيلتر، الكوليسترول من ١٤٧,١ ملجم/

seventy-one (18.8%) had complete remission, and 21 (5.6%) had partial remission from diabetes in the last follow-up. Significant decrease shown in predicted ten-years risk of cardiovascular disease from 7.4% to 5.5% ($p<0.001$).

**Conclusion:**
Obesity-related cardiovascular risk factors can be controlled significantly after bariatric surgeries. It also decreasing ten-years predicted cardiovascular disease risk within short term follow-up.

**Key words:**
Bariatric Surgeries, Cardiovascular Risk, Diabetes, Hypertension

ديسيلتر إلى ١٣٧,٧ ملجم/ديسيلتر، والدهون الثلاثية من ١٢٣,٦ ملجم/ديسيلتر إلى ٧٨,٥ ملجم/ديسيلتر وذلك بعد مرور عام على وقت العملية الجراحية. سبعةٌ وخمسون مريضاً من المصابين بارتفاع ضغط الدم تماثلوا للشفاء التام من بين ٧٩ مريضاً إثر إجراء عمليات السمنة. على صعيدٍ آخر، قُدرت نسبة الشفاء الكلي من مرضى داء السكري ١٨,٨٪ بما يعادل ٧١ مريضاً، و٥,٦٪ كشفاء جزئي بما يعادل ٢١ مريضاً. وتكللت الدراسة بإثبات أن نسبة الإصابة بأمراض القلب والأوعية الدموية المتوقعة في العشر سنوات قد تناقصت من ٧,٤٪ إلى ٥,٥٪ بعد إجراء عمليات السمنة.

**الخلاصة:**
أثبتت الدراسة أن عمليات السمنة بين المصابين بالأمراض المزمنة قد أدت إلى تحسن ملحوظ في كلاً من: عوامل الخطورة المرتبطة بالسمنة المؤدية إلى أمراض القلب والأوعية الدموية ونسبة الإصابة بأمراض القلب والأوعية الدموية المتوقعة في العشر سنوات القادمة، مثبته بدلالة إحصائية.

## Introduction

Obesity is a common disease and is associated with many cardiac risk factors such as hypertension, dyslipidemia, and diabetes. Cardiovascular diseases (CVD) contribute to 31% of all deaths worldwide and 45% of deaths in the Gulf Council Countries (GCC) [1-4]. Studies conducted in Saudi Arabia have revealed that the prevalence of the cardiac risk factors is increasing [5-7].

Despite changing the lifestyle in terms of diet and exercise or using drug treatments to reduce obesity, weight is usually regained within a year [8]. Currently, bariatric surgeries are more widespread between obese individuals and believed to play an important role in the cure and control of cardiovascular risk factors [9]. There are different types of bariatric surgeries including sleeve gastrectomy and gastric bypass. The extent of weight loss depends on the type of the surgery used. Gastric bypass operation (Roux-en-Y Gastric bypass) cause excess weight loss of around 60-80 % [10]. According to Lee et al., the mean body weight loss was 31.4% for sleeve gastrectomy and 37.1% for mini-gastric bypass one year after each surgery [11].

In gastric sleeve surgery, the effect of surgery on glycemic control may be achieved by increasing insulin sensitivity and decreasing insulin resistance [12]. But, in the case of biliointestinal bypass, glycemic control may be achieved by decreasing the fasting blood glucose three months after the surgery by decreasing fat absorption which subsequently leads to reduce insulin hypersecretion and improve insulin sensitivity [13]. In addition, it has been reported that 59% of patients who did laparoscopic gastric sleeve showed evidence of diabetes remission [14].

Moreover, it has been demonstrated that recovery from diabetes, hypertension, and hypertriglyceridemia can be achieved 2 years post-operatively [15]. Carson et al. noticed that 54% of hypertensive patients recovered from hypertension and 22% had improvement in their blood pressure readings [16]. Lipid profile was also found to become normal in most of the cases (84%) who had successful weight loss after bariatric surgery [17].

Although bariatric surgeries are on the rise in Saudi Arabia, only a few studies have reported the follow-up of such patients. Our study focuses on bariatric surgery patients from a tertiary health care center in Makkah, Saudi Arabia. In our study, we describe the effect of bariatric surgeries on different cardiovascular risk factors.

## Methods

*Data source*

This retrospective cohort study including a patient who underwent bariatric surgery at King Abdullah Medical City (KAMC) in Makkah, Saudi Arabia between January 2013 and February, 2016. KAMC is considered as a tertiary care center and a referral hospital that receives patients from a wide area of western Saudi Arabia. Patients of both genders were included in this study, but those aged less than 18 years at the time of surgery were excluded. Prior to start the study, ethical approval was gained from the Institutional Review Board at KAMC. Data was collected from all the patients' files and then entered into an SPSS database.

*Data collection*

The following data was collected: height, weight, blood pressure, fasting blood glucose (FBG), lipid profile, and glycosylated hemoglobin (HbA1c). Baseline data were collected from the pre-operative medical assessments done a few days before surgery. Post-operative data were collected from bariatric clinic follow-up records at 3, 6, 12, and 24 months after surgery.

The comorbidities were defined by the following criteria: diabetes was defined by a HbA1c ≥6.5% as many patients had not done the FBG test, hypertension by the use of antihypertensive medications, and dyslipidemia by a total cholesterol >239 mg/dl, triglyceride (TAG) ≥200 mg/dl, low-density lipoprotein (LDL) cholesterol ≥160 mg/dl, or high-density lipoprotein (HDL) cholesterol <40 mg/dl. Remission of hypertension was defined by the patient quitting anti-hypertensive medications. For dyslipidemia, remission was defined as the return of lipid profile values to normal as per guidelines. For diabetes, the remission criteria of the American Diabetes Association was used, where HbA1c <6 % without any drugs defined as a complete remission, HbA1c 6–6.5 % without any drugs defined as a partial remission, and HbA1c > 6.5 % with or without drugs defined as no remission [18]. The predicted ten-years risk of CVD score was calculated using the age in years, gender, systolic blood pressure measurement, total cholesterol value, HDL cholesterol value, use of anti-hypertensive medications, cigarette smoking, and presence of diabetes according to Framingham heart study (2008) [19].

**Statistical analysis**

Analysis was performed using SPSS, version 21.0 (IBM Inc.). Body Mass Index (BMI) was calculated using height and weight using the below formula:

BMI = weight (kg)/ height2 (m2).

Other weight loss parameters were calculated through the following equations: Absolute weight loss = Weight at baseline – weight at each time point (3, 6, 12, 24 months).

Percentage of weight loss = [(Weight at baseline – weight at each time point) / (Weight at baseline)]

Percentage of excess weight loss = [(Weight at baseline – weight at each time point) / (excess weight)] , where

excess weight = Actual weight - ideal body weight

Percentage of excess BMI loss = [(BMI at baseline – BMI at each time point) / (excess BMI)], where excess BMI = Actual BMI - the ideal BMI

Numeric data presented as mean ± standard deviation (SD). Differences between baseline values and values at 3, 6, 12, 24 months post-operative were assessed by ANOVA with repeated measures. The paired t-test was used for pre-operative and 12 months post-operative values. For variables with non-normally distributed data, non-parametric repeated measure tests, such as sign test, were used. For comparing categorical variables, the chi-square test was used. Two-sided alpha was set as 0.05.

## Results

A total of 566 patients records fit the eligibility criteria. The mean age of the included patients was 34.8±10.2 years (18.04 – 78.2 years). Most of the patients were females (58.1%; n=329), Saudis (93.5%; n=529) and non-smokers (67%; n=379). Table 1 summarizes the characteristics of the patients. Diabetes mellitus patients (24.8%; n=118) and patients with hypertension (18.9%; n=107) were on the top of the obesity-related co-morbidities. Only 3.9% (n=22) of the patients had chronic heart disease, but 12.3% (n=62), 37.7% (n=191), 14.6% (n=71), and 11.1% (n=56) of the patients had hypercholesterolemia, low HDL, high LDL and hypertriglyceridemia, respectively.

Regarding the type of surgery, 95.9 % of the patients (n=543) underwent laparoscopic sleeve gastrectomy, 2.5% (n=14) underwent laparoscopic Roux-en-Y gastric bypass, and 1.6% (n=9) underwent laparoscopic mini-gastric bypass. Patients underwent laparoscopic sleeve gastrectomy developed some complications during and after the surgery such as: two patients had leakage, two patients got bleeding, ten patients developed gastro-esophageal reflux disease, and six patients developed other complications such as obstruction, ulceration, perforation, post-gastric surgery syndrome, and incisional hernia. Furthermore, two patients developed anastomotic ulcer and obstruction post laparoscopic mini-gastric bypass.

Table 1 : Characteristics of the studied patients

| | Characteristic | n (%) |
|---|---|---|
| Gender n=566 | Male | 237 (41.9) |
| | Female | 329 (58.1) |
| Smoking n=566 | Smoker | 152 (26.9) |
| | Ex-smoker | 35 (6.2) |
| | Non-smoker | 379 (67.0) |
| Type of surgery n= 566 | Laparoscopic sleeve gastrectomy | 543 (95.9) |
| | Laparoscopic Roux-en-Y gastric bypass | 14 (2.5) |
| | Laparoscopic mini gastric bypass | 9 (1.6) |
| Comorbidities | Diabetes (n= 475) | 118 (24.8) |
| | Hypertension (n= 566) | 107 (18.9) |
| | Chronic Heart Disease (n= 566) | 22 (3.9) |
| | Hypercholesteremia (n= 504) | 62 (12.3) |
| | Low HDL (n= 506) | 191 (37.7) |
| | High LDL (n= 485) | 71 (14.6) |
| | Hypertriglyceridemia (n= 506) | 56 (11.1) |

n number of patients with available data for each parameter

Figures 1.1 and 1.2 show the changes in weight and lipid profile parameters over time. The number of patients who had regular post-operative follow-up at 3, 6, 12, 24 months was small. Weight and BMI recordings were available for 49 patients, and these variables showed a statistically significant decrease from 129.1±20.1 kg and 47.6±7.6 kg/m2 at baseline to 87±15.5 kg and 31.8±6 kg/m2, respectively, at 24 months ($p<0.001$). This was coupled with a statistically significant increase in weight loss parameters (absolute weight loss, percentage of weight loss, percentage of excess weight loss and Percentage of excess BMI loss). The decrease in weight and BMI and the increase in weight loss parameters were the steepest initially and approached a plateau at one-year post-operative, after which the rate of changes reduced.

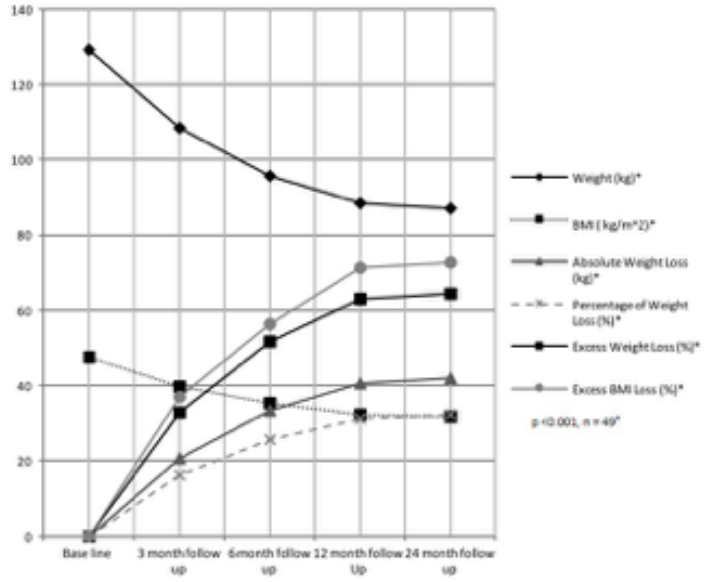
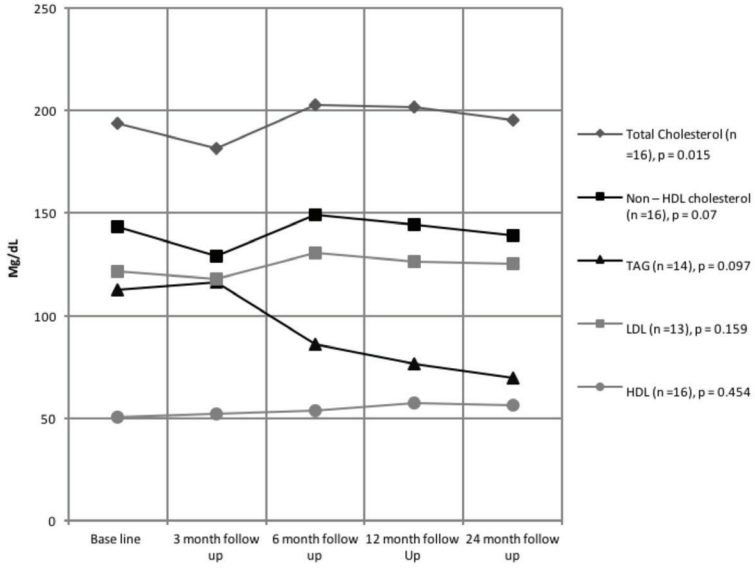



**Fig. 1.1** Change in weight and BMI over 24 months of post-operative follow up




*HDL* high density lipoprotein, *LDL* low density lipoprotein, *TAG* triglyceride, n number of patients with available data for each parameter

**Fig. 1.2** Change in Lipid Profile over 24 Months of Post-operative Follow Up

Changes in lipid profile were less consistent over time as shown in Figure 1.2 Total cholesterol showed an overall statistically significant decrease (p=0.015). Although statically significance could not be achieved with other lipid profile parameters, the TAG decreased from 112.7±46.1 mg/dl to 69.7±31.6 mg/dl (n=14, P=0.09) and the HDL increased from 50.4±14.4 mg/dl to 56.5±11.8 mg/dl (n=16, P=0.45). Although regular HbA1c values were completed only in 11 patients, there was a statistically significant decrease from 6.8±1.3% at baseline to 5.7±0.4% at 24 months (p<0.001). The blood pressure measurements were available for 19 patients and showed a mild reduction for both systolic and diastolic readings from 132.8±14.1 mm Hg to 125.5±17.9 mm Hg for systolic blood pressure (P=0.28) and from 70.3±10.7 mm Hg to 66.3±11.2 mm Hg (P=0.17) for diastolic blood pressure over 24 months follow-up after surgery.

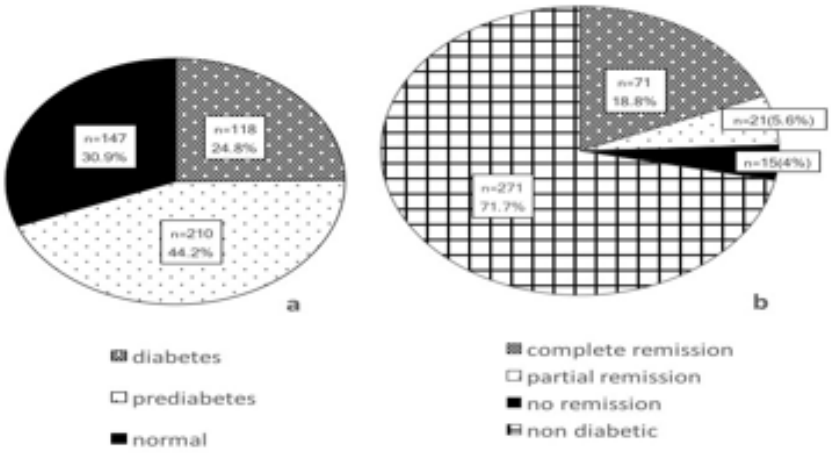



**Fig. 2.1 a** Diabetic status at baseline, **b** Postoperative diabetic status

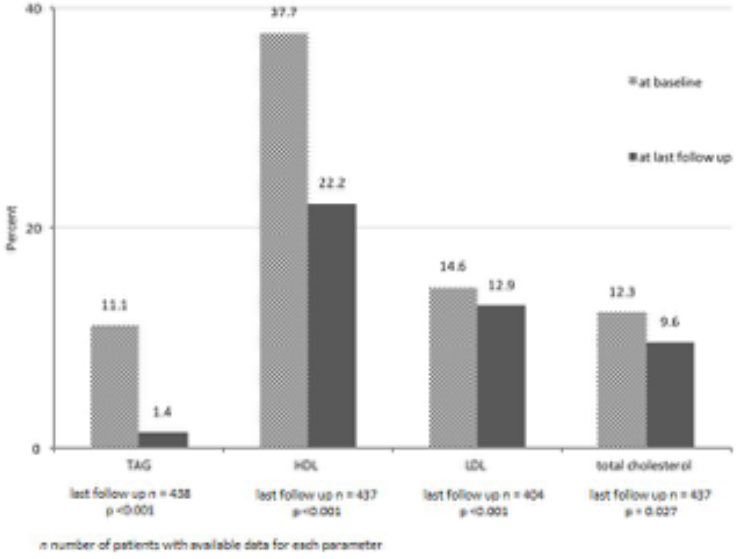



**Fig. 2.2** Percentage of patients with abnormal lipid profile variables at pre-operative and post-operative measurements

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Table 2 focuses on changes captured at 12 months of follow-up and so it makes use of the relatively bigger number of cases with available follow-up values. There were only a few patients with FBG measurements as it was not done routinely for each patient during their follow-up. Lipid profile of patients improved significantly at one year of post-operative follow-up as the mean HDL increased to 52.3 mg/dl and the mean non-HDL cholesterol decreased to 137.7 mg/dl.

Out of 79 patients who were hypertensive at baseline, 57 (72.2%) became normotensive and quit their medication by the time of the last follow-up, within two years after surgery (p<0.001). It can be seen from the data in Figure 2.1.b that 18.8% (n=71) of patients had complete remission from diabetes two years postoperative. Many patients with dyslipidemia had their lipid profile normalized Figure 2.2. Also, the ten-years predicted cardiovascular risk decreased from 7.4±8.1% to 5.5±5.3% (n=96, p<0.001) by the time of the last follow-up.

Table 2 Comparison between Cardiovascular Risk Factors at Baseline and at 12 Months Post-operative.

| Test | Baseline (Mean±SD) | 12 Months Follow-Up (Mean±SD) | Mean difference | P value |
|---|---|---|---|---|
| Weight (kg) n=274 | 127.9±23.8 | 85.8±17.6 | 42.1 | <0.001* |
| BMI (kg/m2) n=273 | 47.3±7.4 | 31.8±6.4 | 15.5 | <0.001* |
| Systolic BP (mm Hg) n=175 | 129.8±14.2 | 125.5±16.3 | 4.3 | 0.005* |
| Diastolic BP (mm Hg) n=175 | 71.0±13.4 | 70.5±13.9 | 0.5 | 0.076 |
| HbA1c (%) n=207 | 6.4±1.4 | 5.4±0.6 | 1.05 | <0.001* |
| FBG (mg/dl) n=7 | 126.0±36.0 | 86.3±9.4 | 39.7 | 0.020* |
| Total cholesterol (mg/dl) n=222 | 191.6±35.5 | 190.0±32.4 | 1.6 | 0.257 |
| Non – HDL cholesterol (mg/dl) n=222 | 147.1±35.8 | 137.7±31.2 | 9.3 | <0.001* |
| HDL (mg/dl) n=223 | 44.4±12.3 | 52.3±13.0 | (-7.9) | <0.001* |
| LDL (mg/dl) n=191 | 121.9±33.2 | 120.5±29.6 | 1.4 | 0.596 |
| Triglyceride (mg/dl) n=221 | 123.6±83.4 | 78.5±31.5 | 45.1 | <0.001* |

BP Blood pressure, HbA1c Glycosylated hemoglobin, FBG Fasting Blood Glucose, HDL High density lipoprotein, LDL Low density lipoprotein, *statistically significant, n number of patients with available data for each parameter, SD standard deviation

## Discussion

Surgical treatment of obesity dates back to 1953 when the first induced malabsorption for weight loss was performed. This procedure resulted in marked weight reduction; nevertheless, it sometimes resulted in nutritional complications. The bariatric surgery field has grown over the past 50 years, and weight loss has almost been outshined by the effects of obesity-related comorbidities such as hyperlipidemia, hypertension, and diabetes. Recently, the interest in finding the impact of weight loss achieved by surgical methods on cardiovascular risk factors using different biomarkers has increased [20].

In this study, we reviewed the effect of bariatric surgery on different cardiovascular risk factors. The obtained data clearly showed 23% reduction in the overall BMI at one year after surgery. In diabetics, there were also great reductions in HbA1c. These results are consistent with the results described by Gulliford et al. in a study that included diabetic patients, and in which they found that the mean HbA1c reduced from 8% to 6.8 % and 6.5 % at one and two years, respectively, after bariatric surgery [21]. Similarly, Mihmanli et al. stated that the HbA1c after laparoscopic sleeve gastrectomy decreased to 5.5% on the 6th month and 5.2% on the 12th month [22]. Other diabetes measurements in the present study also showed great reductions such as the mean fasting blood sugar which decreased from 126 to 86.3 mg/dl by the 12th month. Similarly, Mihmanli et al. found that fasting plasma glucose decreased to 92.29 mg/dl six months after laparoscopic sleeve gastrectomy and to 87.94 mg/dl one year after surgery [22].

In this study, there was a clear improvement in lipid parameters as well. This result is similar to what was found by Vogel et al. [23] and Buchwald et al. who showed a remarkable effect of bariatric surgery on lipid levels among patients with hyperlipidemia [24]. With regard to the arterial blood pressure, a significant decrease was achieved only in systolic blood pressure after 12 months follow-up in the present study. The decline in diastolic blood pressure and the changes over 2 years may have needed a bigger study sample to achieve statistical significance. Yet, there was a general trend of reduction in the arterial blood pressure. Vogel et al. found that the blood pressure measurement among 109 obese patients revealed a significant decline in systolic and diastolic blood pressure from 133 mmHg and 80 mmHg to reach 116 mmHg and 71 mmHg, respectively [23].

The results obtained through this study revealed that the 10-year predicted cardiovascular risk by Framingham score decreased from 7.4% to 5.5%. This impressive reduction following bariatric surgery sheds light on the significant impact of bariatric surgeries on comorbidities prevention. In a large study comparing cardiovascular outcomes between obese individuals treated with bariatric surgery and non-surgically treated individuals, Sampalis et al. revealed a notable reduction in the treatment of different cardiovascular situations such as ischemic heart disease among those who treated surgically. [25]. Many other studies found great reductions in the 10-year risk factor as those done by Torquati et al. [26], Batsis et al. [27] and Eliasson et al. [28].

Long-term effects after bariatric surgery should be examined as obesity is a chronic disease [29]. The 2-years follow-up data obtained through this study revealed that 72.2% of the hypertensive patients quit their medication completely ($P<0.001$), and 18.8% of patients had complete remission from diabetes. Furthermore, there was a great improvement in the lipid profile for the patients. Similarly, Sjöström et al. in their non-randomized matched study found that all the 2-year rates of improvement for the studied risk factors were better in the surgery group compared to the control group [15]. They observed that gas-

tric bypass surgery has a significant effect on the rate of diabetes and mortality [30].

It is obvious that bariatric surgery has a more influential impact than those achieved by other methods. the effects of medications are reliant on patients' compliance, and the benefits may achieve persevere during the period of treatment. In general, surgical intervention is considered a good choice for obese individuals and should be considered as a life-saving and preventive intervention in preference to a cosmetic surgery.

There were some limitations to our study. The available literature does not show clear criteria to examine obesity comorbidities. Some articles used laboratory data for diabetes and blood pressure measurements for hypertension; however, others used patient history and medications for diagnosis. Another limitation was that not all the patients were available for regular post-operative follow-up. Moreover, the literature reported the data on weight loss and co-morbidity in several and variable formats using descriptive and non-numeric data which hinder the comparison of the obtained results in this study with others. The maintenance of all these changes needs a longer time of follow-up.

## Conclusion

Bariatric surgeries are significantly effective for remission and controlling of obesity-related cardiovascular comorbidities, including diabetes, hypertension, and dyslipidemia, and decreases its 10-year predicted risk within a 24 months follow-up period.

It is obvious that a set of standardized formats for reporting such data related to weight loss and comorbidities is needed. In addition, future studies should focus on the biochemical verification for resolution or reduction of obesity-related comorbidities. Also, further prospective studies are recommended with strict follow up to detect which type of patients benefit more and which risk factors are associated with less benefit after bariatric surgery.

Studies to compare the advantages of each type of bariatric surgery are needed with longer follow-up periods.

## Conflict of Interest

The authors declare no conflict of interest.

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