



# Effect of laparoscopic mini-gastric bypass versus laparoscopic sleeve gastrectomy on hypertension and dyslipidemia in obese type 2 diabetes mellitus patients

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**Objective:** The aim of the research was to compare the effect of the laparoscopic mini-gastric bypass (LMGB) technique with the laparoscopic sleeve gastrectomy (LSG) technique in bariatric surgery on type 2 diabetes mellitus (T2DM), hypertension (HTN), and dyslipidemia in obese T2DM patients.

**Materials and methods:** A prospective, cross-sectional study, conducted in Surgery Department at Al-Mouwasat and Al-Assad University Hospitals in Damascus, and included T2DM obese patients who would undergo bariatric surgery using the LMGB or LSG technique.

**Results:** The research included two groups: the LSG group (92 patients, 60.9% female, age 44.6 year, BMI 41.85 kg/m<sup>2</sup>) and the LMGB group (137 patients, 59.1% female, age 47.1 year, BMI 43 kg/m<sup>2</sup>). Before surgery, the prevalence of HTN and dyslipidemia were similar in the two groups. After one year: T2DM improvement and remission rate in the LMGB group (13.9, 80.3%) were greater than in the LSG group (13, 62%), the difference was statistically significant. The HTN improvement and remission rate in the LMGB group (52.9, 41.4%) were greater than in the LSG group (47.5, 39%), the difference was not statistically significant. The dyslipidemia improvement rate was greater in LSG group (47.2 vs. 32.7%), while the dyslipidemia remission rate was greater in LMGB group (67.3 vs. 52.8%), the difference was statistically significant.

**Conclusions:** The authors found that the LMGB technique was more effective than the LSG technique in controlling cardiovascular risk factors of obesity, T2DM, HTN, and dyslipidemia.

**Keywords:** dyslipidemia, hypertension, laparoscopic mini-gastric bypass (LMGB), laparoscopic sleeve gastrectomy (LSG), type 2 diabetes mellitus

## Introduction

Obesity and type 2 diabetes mellitus (T2DM) are two of the most common metabolic disorders in the world, and both have significantly increased in the last decades<sup>[1–3]</sup>.

The obesity prevalence among adults (> 18 years) in Syria increased from 15.2 in 2000 to 25.8% in 2016<sup>[4]</sup>.

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## HIGHLIGHTS

- One year after surgery, the laparoscopic mini-gastric bypass (LMGB) group had a greater percentage of excess weight loss and higher high-density cholesterol levels compared to the laparoscopic sleeve gastrectomy (LSG) group, and the differences were statistically significant.
- The LMGB group had a higher type 2 diabetes mellitus remission rate (80.3%) compared to the LSG group (62%), and the difference was statistically significant.
- There was no statistically significant difference in hypertension improvement and remission rates between the two groups.
- The LMGB group had a higher dyslipidemia remission rate (52.8%) compared to the LSG group (34.7%), and the difference was statistically significant.
- The results suggest that LMGB is more effective than LSG in terms of type 2 diabetes mellitus remission and dyslipidemia remission.

Obesity is closely associated with hypertension (HTN), as well as other cardiovascular risk factors such as dyslipidemia and T2DM<sup>[5,6]</sup>.

HTN in obesity is attributed to an increase in blood plasma volume and cardiac output due to an increase in body mass with a

decrease in urine and an increase in sodium reabsorption due to the activation of the renin–angiotensin–aldosterone axis and the sympathetic nervous system<sup>[7,8]</sup>.

Bariatric surgery is currently the only effective long-term treatment for morbid obesity and associated comorbidities such as diabetes, HTN, and dyslipidemia<sup>[9,10]</sup>.

Different laparoscopic bariatric procedures have been investigated to treat T2DM obese patients, with excellent results in terms of weight loss and glycemic control reported for both the biliopancreatic diversion with or without the duodenal switch (BPD/BPD-DS) and the Roux-en-Y gastric bypass (RYGBP)<sup>[11,12]</sup>. Conversely, restrictive procedures such as the laparoscopic sleeve gastrectomy (LSG) and the laparoscopic adjustable gastric banding, although effective on weight loss, seem to provide different results on T2DM remission. In fact, while the LSG presents an outcome that, in some studies, is comparable to RYGBP<sup>[13–15]</sup>.

The mini-gastric bypass or one anastomosis gastric bypass (MGB/OAGB) originated by Rutledge in 1997 is an emerging technique consisting in a simplified version of the classic RYGBP<sup>[16]</sup>, and when described, MGB/OAGB raised, different authors have reported excellent results in terms of weight loss and resolution of obesity-related comorbidities, including T2DM<sup>[17–19]</sup>.

This research compared the effect of the laparoscopic mini-gastric bypass (LMGB) and LSG techniques on diabetes mellitus, HTN, and dyslipidemia in obese T2DM patients.

## Methods and materials

The research is consistent with the strengthening the reporting of cohort, cross-sectional and case-control studies in Surgery (STROCSS) criteria<sup>[20]</sup>.

A prospective, cross-sectional Study, conducted in the Department of Surgery at Al-Mouwasat and Al-Assad University Hospitals in Damascus, between 1/5/2019 and 1/5/2022.

The research included 229 diabetes mellitus type 2 patients, inclusion criteria: age greater than 20 years, BMI greater than 30 kg/m<sup>2</sup>, HbA1c greater than or equal to 6.5, may have HTN or dyslipidemia) who underwent bariatric surgery (LSG or LMGB),

Exclusion Criteria: presence of contraindications for surgery, discontinuation of follow-up one year after the operation, data incomplete. The patient refused to participate in the research.

The patients were randomly distributed to the two research groups, but the surgical technique was changed at the request of some patients (23 patients) and patient withdrew from the study.

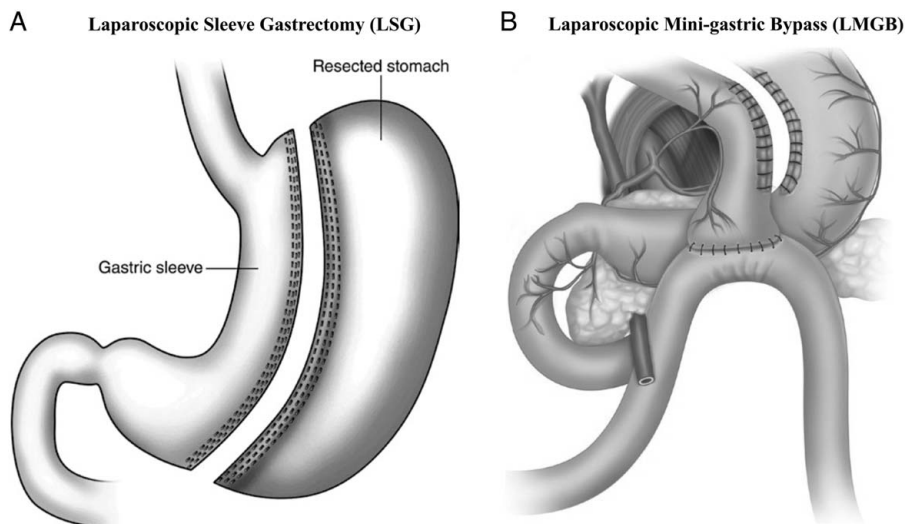
## Operative technique

### Laparoscopic mini-gastric bypass

The technique used for LMGB is a five-port technique similar to that reported by Rutledge. The gastric tube was created by applying one horizontal 45 mm Roticulator Endo-GIA at the level of the crow's foot and four to five vertical 60 mm Endo-GIA upward to the angle of His. An antecolic loop end-to-side gastroenterostomy was created with the jejunum at 150–200 cm (and increased by 10 cm for each BMI point above 40) distal to the ligament of Treitz and the gastric tube by using a posterior 45 mm roticulator Endo-GIA stapler and an anterior hand sutures. Intraoperative methylene blue test for leak was performed in all patients. No naso-gastric tube or abdominal drainage were left in place (Fig. 1).

### Laparoscopic sleeve gastrectomy

The operation was performed in reverse trendelenburg position on an operating table and the surgeon takes position between the legs of the patient. The 4–5-trocar technique is used. The omentum was released and ligated from the greater gastric curvature with the energy-based device continuing proximally into the esophagus and 6 cm proximal to the pylorus, until the angle of His was completely released and the left diaphragmatic peduncle was exposed. After the dissection of the greater curvature, a calibrating bougie (36F) is placed at the stomach and passed through the pylorus. The stomach was cut along the large curvature and at the edge of the gastric tube inserted through the endoscopic stacker. A methylene blue test was performed to detect leakage. The removed part of the stomach was removed from the abdomen.



**Figure 1.** Diagram (A) showing a longitudinal gastrectomy; (B) demonstrating the MGB mini-gastric bypass process.

### Data and follow-up

Before the surgery, a clinical history was taken, including recording age, sex, height, weight, and BMI, systolic blood pressure (SBP), diastolic blood pressure (DBP), and laboratory tests results [fasting plasma glucose, glycohemoglobin A1C, low-density cholesterol, high-density cholesterol, and triglycerides (TG)].

Patients were followed up in cooperation with endocrinologists and nutritionists to establish a unified diet. Patients of both groups received instructions about diet before and after surgery, including the following:

- (1) Absolute diet until the first morning after surgery.
- (2) The first month: the clear liquid diet for 2 weeks, then the thick liquid diet for 2 weeks as well.
- (3) In the second month, follow a soft meal diet for a month.
- (4) It is recommended to eat 4–5 small meals a day, in addition to drinking 6–8 glasses of water or warm, low-sugar drinks, and restricting sugar and carbohydrate intake.
- (5) It is recommended to take nutritional supplements that contain vitamins and minerals (liquid or chewable for the first month, then in pill form) with regular dose adjustments according to the recommendations of a nutritionist.
- (6) Maintaining physical activity and exercising at a rate of at least 150 min per week.

Patients were followed up after 12 months, where weight, BMI, SBP, DBP, and laboratory tests results (fasting plasma glucose, glycohemoglobin A1C, low-density cholesterol, high-density cholesterol, TG) were recorded.

### Criteria

Diabetes mellitus: presence of one of the following criteria in a patient with diabetes classic symptoms (polyuria, polydipsia, weight loss, and blurred vision)<sup>[21]</sup>:

- (1) Fasting plasma glucose (FPG) greater than or equal to 126 mg/dl.
- (2) Glycohemoglobin A1C greater than or equal to 6.5%.
- (3) Random plasma glucose titration greater than or equal to 200 mg/dl.

In the absence of obvious symptoms, the titration should be repeated on another sample on a later day, and if there are two results of two different tests that indicate the diagnosis of diabetes.

### Diabetes mellitus remission

It is considered that there is an T2DM remission if FPG less than 126 mg/dl and HbA1c less than 6.5% without taking oral hypoglycemic drugs or insulin, and it is considered that there is an T2DM improvement if the patient was not treated with insulin, even if he takes oral hypoglycemic drugs<sup>[22]</sup>.

Dyslipidemia in a patient with type 2 diabetes: if the patient is previously diagnosed with dyslipidemia or has one of the following<sup>[21,23]</sup>:

- (1) Total cholesterol greater than or equal to 150 mg/dl.
- (2) Low-density cholesterol (LDL) greater than or equal to 100 mg/dl.
- (3) High-density cholesterol (HDL) less than 40 mg/dl for males and less than 50 mg/dl for females.
- (4) TG greater than or equal to 150 mg/dl.

### Dyslipidemia remission

It is considered remission if the following criteria are met after surgery without the patient taking anticholesterol or anti-triglyceride drugs. It was considered that there was an dyslipidemia improvement if the following criteria are met with the patient taking anticholesterol or antitriglyceride drugs<sup>[21,23]</sup>:

- (1) Total cholesterol less than 150 mg/dl.
- (2) LDL less than 100 mg/dl.
- (3) HDL greater than or equal to 40 mg/dl for males and greater than or equal to 50 mg/dl for females.
- (4) TG less than 150 mg/dl.

### Hypertension

The patient is considered to have arterial HTN if<sup>[24–26]</sup>:

- (1) A patient previously diagnosed with HTN, treated or untreated.
- (2) Stage 1 – Systolic 130–139 mmHg or diastolic 80–89 mmHg.
- (3) Stage 2 – Systolic at least 140 mmHg or diastolic at least 90 mmHg.

### Hypertension improvement

It is considered that there is an improvement in HTN if blood pressure control improved with/without fewer antihypertensive drugs or a smaller dose.

### Hypertension remission

It is considered HTN remission if SBP less than or equal to 130 mmHg and DBP less than or equal to 80 mmHg without taking antihypertensive drugs.

Percentage of excess weight loss =  $\frac{[\text{Preoperative weight} - \text{follow-up weight}]}{[\text{preoperative weight} - 25 \times \text{height (cm)}]} \times 100$ .

### Statistical analysis

Data was analyzed using the Statistical Package for Social Sciences version 25.0 (SPSS Inc.). Data was reported as frequencies and percentages (for categorical variables) or means, medians, and SD (for continuous variables). The relationship between independent variables and the mean knowledge scores was assessed using the independent samples *t*-test and the Pearson  $\chi^2$ -test. *P*-values <0.05 was considered statistically significant.

### Sample size

The minimum sample size was calculated using the Richard Geiger equation as follows:

$$n = \frac{\left(\frac{z}{d}\right)^2 \times P(1 - P)}{1 + \frac{1}{N} \left[\left(\frac{z}{d}\right)^2 \times P(1 - P) - 1\right]},$$

Where *N* is the size of the community = 570, *P* the property and neutral availability ratio = 0.50, *Z* the standardized confidence level score of 0.95 equal to 1.96, and *d* is the error ratio of 0.05.

Thus, the minimum required sample size is 229 patients.

## Results

The research included 229 patients, divided into two groups: the LSG group (92 patients) and the LMGB group (137 patients).

The female proportion was greater in the LSG group, while the mean age was greater in the LMGB group, but the difference was not statistically significant.

HTN prevalence was greater in the LSG group, while the dyslipidemia prevalence was greater in the LMGB group, the difference was not statistically significant.

Before surgery, mean height, weight, and FPG were greater in the LSG group, while mean BMI, SBP, HbA1c, LDL-cholesterol, HDL-cholesterol, and TG were greater in the LMGB group, the difference was not statistically significant.

One year after surgery, mean weight, BMI, FPG, HbA1c, and LDL-cholesterol were greater in the LSG group, while mean excess weight loss and HDL-cholesterol were greater in the LMGB group, the difference was statistically significant.

After surgery, mean DBP and TG were greater in LSG group, while mean SBP was greater in LMGB group, the difference was not statistically significant.

Table 1 shows the characteristics and comparison of the studied variables before and one year after surgery.

**Table 1**  
Characteristics and comparison of the age, sex, comorbidities, body measurements, blood pressure, and laboratory test results before and 1 year after surgery

|                          | Total (229)    | LSG (92)       | LMGB (137)     |         |
|--------------------------|----------------|----------------|----------------|---------|
|                          | Mean/N (SD/%)  | Mean/N (SD/%)  | Mean/N (SD/%)  | P       |
| Age (years)              | 46.1 (10.9)    | 44.6 (10.9)    | 47.1 (10.8)    | 0.087   |
| Female                   | 137 (59.8)     | 56 (60.9)      | 81 (59.1)      | 0.792   |
| Male                     | 92 (40.2)      | 36 (39.1)      | 56 (40.9)      |         |
| HTN                      | 146 (63.8)     | 59 (64.1)      | 87 (63.5)      | 0.923   |
| Dyslipidemia             | 182 (79.5)     | 72 (78.3)      | 110 (80.3%)    | 0.709   |
| Presurgery               |                |                |                |         |
| Height (cm)              | 168.58 (8.4)   | 169.39 (8.53)  | 168.03 (8.3)   | 0.230   |
| Weight (kg)              | 122.1 (21.57)  | 122.97 (17.3)  | 121.51 (24.07) | 0.631   |
| BMI (kg/m <sup>2</sup> ) | 42.96 (6.86)   | 42.85 (5.02)   | 43.04 (7.87)   | 0.831   |
| SBP (mmHg)               | 137.29 (16.79) | 136.52 (16.44) | 137.81 (17.06) | 0.570   |
| DBP (mmHg)               | 85.74 (7.09)   | 84.95 (6.4)    | 86.28 (7.5)    | 0.164   |
| FPG (mg/dl)              | 245.75 (62.18) | 247.12 (69.75) | 244.82 (56.78) | 0.785   |
| HbA1c (%)                | 8.35 (0.76)    | 8.33 (0.78)    | 8.36 (0.75)    | 0.799   |
| LDL (mg/dl)              | 127.65 (34.57) | 125.29 (33.29) | 129.2 (35.43)  | 0.399   |
| HDL (mg/dl)              | 42.67 (7.75)   | 42.47 (7.93)   | 42.81 (7.65)   | 0.743   |
| TG (mg/dl)               | 150.62 (44.7)  | 149.58 (45.31) | 151.33 (44.53) | 0.772   |
| One year after surgery   |                |                |                |         |
| Weight (kg)              | 77.86 (9.19)   | 82.22 (8.25)   | 74.93 (8.64)   | < 0.001 |
| BMI (kg/m <sup>2</sup> ) | 27.35 (2.06)   | 28.65 (1.96)   | 26.48 (1.62)   | < 0.001 |
| EWL (%)                  | 86.88 (9.73)   | 79.89 (7.64)   | 91.58 (8.03)   | < 0.001 |
| SBP (mmHg)               | 126.53 (10.96) | 126.30 (9.97)  | 126.68 (11.60) | 0.800   |
| DBP (mmHg)               | 78.89 (5.79)   | 79.13 (6.32)   | 78.72 (5.42)   | 0.602   |
| FPG (mg/dl)              | 102.20 (20.02) | 109.10 (24.06) | 97.57 (15.20)  | < 0.001 |
| HbA1c (%)                | 6.05 (0.50)    | 6.23 (0.51)    | 5.92 (0.46)    | < 0.001 |
| LDL (mg/dl)              | 92.48 (23.89)  | 98.60 (23.77)  | 88.38 (23.16)  | 0.001   |
| HDL (mg/dl)              | 48.66 (7.26)   | 47.34 (7.62)   | 49.55 (6.88)   | 0.023   |
| TG (mg/dl)               | 120.64 (17.88) | 121.62 (18.16) | 119.98 (17.73) | 0.497   |

Bold values are statistically significant of *P*-values < 0.05.

DBP, diastolic blood pressure; EWL, excess weight loss; FPG, fasting plasma glucose; HbA1c, glycohemoglobin A1C; HDL, high-density cholesterol; HTN, hypertension; LDL, low-density cholesterol; LMGB, laparoscopic mini-gastric bypass; LSG, laparoscopic sleeve gastrectomy; SBP, systolic blood pressure; TG, triglycerides.

In the LSG group, the T2DM improvement rate was 13%, the remission rate was 62%, and in the LMGB group, the T2DM improvement rate was 13.9%, while the T2DM remission rate was very high (80.3%), the difference was statistically significant.

In the LSG group, the HTN improvement rate was 47.5 and the remission rate was 39%. Similarly, in the LMGB group, the HTN improvement rate was 52.9 and the remission rate was 41.4%. The difference was not statistically significant.

In the LSG group, the dyslipidemia improvement rate was 47.2 and the remission rate was 52.8%, while in the LMGB group, the dyslipidemia improvement rate was 32.7 and the remission rate was 67.3%, the difference was statistically significant.

Table 2 shows a comparison of the surgery effect after 1 year on T2DM, HTN, and dyslipidemia.

The incidence of short-term complications (thrombophlebitis or pulmonary embolus) was small in the two groups, and the difference between them was not statistically significant. We note that these cases were treated conservatively and responded well.

The formation of gallstones after surgery was at a higher rate in the LMGB group, while the formation of urinary stones was at a higher rate in the LSG group, the difference was not statistically significant.

The incidence of gastroesophageal reflux is greater in the LSG group, while the incidence of biliary regurgitation is greater in the LMGB group, and we mention that PPIs were treated until the end of the follow-up period, and metoclopramide was used for some patients with good tolerance of symptoms.

The incidence of depression was greater in the LSG group, but the difference was not statistically significant. We mention that all cases were cured within 6 months of follow-up.

The mean duration of hospitalization was similar in the two groups, and the difference was not statistically significant. No cases of death, alcohol addiction, or self-harm were recorded during the follow-up period.

Table 3 shows a comparison of complications and the duration of hospitalization.

**Table 2**  
Comparing the effect of surgery after 1 year on diabetes, HTN, and dyslipidemia

|                               | Total          |              | LSG            | LMGB    |   |
|-------------------------------|----------------|--------------|----------------|---------|---|
|                               | N (%)          | N (%)        | N (%)          |         | P |
| T2DM no improvement           | 31/229 (13.5)  | 23/92 (25)   | 8/137 (5.8)    | < 0.001 |   |
| T2DM improvement rate         | 31/229 (13.5)  | 12/92 (13)   | 19/137 (13.9)  |         |   |
| T2DM remission rate           | 167/229 (72.9) | 57/92 (62)   | 110/137 (80.3) |         |   |
| HTN no improvement            | 13/146 (8.9)   | 8/59 (13.6)  | 5/87 (5.7)     | 0.264   |   |
| HTN improvement rate          | 74/146 (50.7)  | 28/59 (47.5) | 46/87 (52.9)   |         |   |
| HTN remission rate            | 59/146 (40.4)  | 23/59 (39)   | 36/87 (41.4)   |         |   |
| Dyslipidemia no improvement   | 0 (0)          | 0 (0)        | 0 (0)          | 0.049   |   |
| Dyslipidemia improvement rate | 70/182 (38.5)  | 34/72 (47.2) | 36/110 (32.7)  |         |   |
| Dyslipidemia remission rate   | 112/182 (61.5) | 38/72 (52.8) | 74/110 (67.3)  |         |   |

Bold values are statistically significant of *P*-values < 0.05.

HTN, hypertension; LMGB, laparoscopic mini-gastric bypass; LSG, laparoscopic sleeve gastrectomy; T2DM, type 2 diabetes mellitus.

**Table 3**  
Comparison of complications and duration of hospitalization

|                             | Total            | LSG              | LMGB             | P                |
|-----------------------------|------------------|------------------|------------------|------------------|
|                             | Mean/N<br>(SD/%) | Mean/N<br>(SD/%) | Mean/N<br>(SD/%) |                  |
| Thrombophlebitis            | 4 (1.7)          | 2 (2.2)          | 2 (1.5)          | 0.686            |
| Pulmonary embolus           | 2 (%)            | 1 (1.1)          | 1 (0.7)          | 0.776            |
| Gallstones                  | 27 (11.8)        | 8 (8.7)          | 19 (13.9)        | 0.234            |
| Kidney stones               | 8 (3.5)          | 5 (5.4)          | 3 (2.2)          | 0.190            |
| Gastroesophageal reflux     | 19 (8.3)         | 15 (16.3)        | 4 (2.9)          | <b>&lt;0.001</b> |
| Biliary reflux              | 17 (7.4)         | 4 (4.3)          | 13 (9.5)         | 0.146            |
| Depression                  | 9 (3.9)          | 5 (5.4)          | 4 (2.9)          | 0.337            |
| Duration of hospitalization | 2.18 (1.35)      | 2.22 (1.39)      | 2.16 (1.33)      | 0.756            |

Bold values are statistically significant of *P*-values < 0.05.

LMGB, laparoscopic mini-gastric bypass; LSG, laparoscopic sleeve gastrectomy.

## Discussion

Obesity, diabetes mellitus, HTN, and dyslipidemia are risk factors for the development of coronary, cerebrovascular, and peripheral artery disease<sup>[5,6]</sup>.

Prolonged elevation of insulin resistance can lead to dyslipidemia. Therefore, obesity and T2DM are risk factors for dyslipidemia<sup>[27]</sup>.

Bariatric surgery, with its effect on reducing body weight, reduces insulin resistance, and thus, in addition to its effect on T2DM, it reduces the risk of dyslipidemia.

Several studies concluded that bariatric surgery effectively led to excess weight loss with a resolution of obesity-related complications in patients, and it is also effective in managing T2DM in obese patients compared to pharmacological management<sup>[28–30]</sup>.

In this research, the percentage of females was similar between the two research groups, as well as the prevalence of HTN and dyslipidemia, and although the mean age of patients was greater in the LMGB group. Also, BMI, SBP, DBP, and laboratory test results were similar in the two research groups.

One year after surgery, the T2DM improvement and remission rate were greater in the LMGB group than in LSG group. Several studies reached similar results<sup>[17,18,30–42]</sup>, where the T2DM remission rate in the LMGB/MGB group (30.6–94.2%) was greater than in the LSG/SG group (23.4–90.8%) (Table 4).

There are several hypotheses about the mechanisms of the effect of bariatric surgery on type 2 diabetes. One proposed mechanism is that visceral fat is an important source of inflammatory cytokines such as tumor necrosis factor- $\alpha$  ( $\alpha$ ), transforming growth factor- $\beta$ , interleukin-6, resistin, and plasminogen activator inhibitor type 1, which can directly affect the uptake of glucose by cells in the target tissues by the effect of insulin (insulin resistance), and also contribute to the decrease in the secretion of other factors such as adiponectin that reduce insulin resistance, and thus bariatric surgery and accompanying weight loss counteract these mechanisms<sup>[44]</sup>.

Another hypothesis is the effect of lipotoxicity, which is characterized by an increase in the distribution of free fatty acids, which leads to progressive damage to cells, including pancreatic alpha ( $\alpha$ ) cells, causing defects in glucagon secretion in individuals genetically predisposed to type 2 diabetes<sup>[45]</sup>.

Another hypothesis is the stomach hypothesis, which says that changes in the secretion of gastric factors due to the cut are responsible for the rapid recovery of insulin and an increase in sensitivity to its effect, and that the main peptide in this mechanism is ghrelin, which is produced from the bottom of the stomach, which is removed in the longitudinal cut of the stomach. From gastric emptying and intestinal transit, which in turn influences gut hormones such as glucagon-like peptide-1 (GLP-1), peptide YY, glucose-dependent insulinotropic polypeptide, and leptin, as well as evidence of an effect of ghrelin on beta ( $\beta$ ) cells as well as on body weight<sup>[46,47]</sup>.

Incretins secreted in the gastrointestinal tract are able to modulate the response of pancreatic islet cells of langerhans, increase insulin and decrease glucagon secretion, which include GLP-1 and glucose-dependent insulinotropic polypeptide, both of which regulate glucose metabolism, and increase secretion

**Table 4**  
Comparison remission rates of type 2 diabetes, hypertension, and dyslipidemia between LSG/SG and LMGB/MGB bariatric surgery techniques in several studies

| References                               | Follow-up period (years) | T2DM remission rate% |          | HTN remission rate% |          | Dyslipidemia remission rate% |          |
|------------------------------------------|--------------------------|----------------------|----------|---------------------|----------|------------------------------|----------|
|                                          |                          | LSG/SG               | LMGB/MGB | LSG/SG              | LMGB/MGB | LSG/SG                       | LMGB/MGB |
| Moustafa <i>et al.</i> <sup>[31]</sup>   | 1                        | 50                   | 60       | 66.7                | 100      | 60                           | 87.5     |
| Khalaj <i>et al.</i> <sup>[32]</sup>     | 1                        | 71.9                 | 65.3     | 52.2                | 52.6     | 27.7                         | 37.1     |
|                                          | 2                        | 53.3                 | 63.8     | 39.1                | 54.7     | 14.2                         | 29.8     |
| Mohamed <i>et al.</i> <sup>[33]</sup>    | 1                        | 50                   | 81.8     | 60                  | 62.5     | 66.7                         | 87.5     |
| Ruiz-Tovar <i>et al.</i> <sup>[34]</sup> | 1                        | 86.9                 | 94.2     | 78.3                | 89.5     | 41.4                         | 100      |
| Mostafa <i>et al.</i> <sup>[35]</sup>    | 1                        | 25                   | 81.8     | 50                  | 62.5     | 16.7                         | 87.5     |
| Alkhalifah <i>et al.</i> <sup>[36]</sup> | 1                        | 90.8                 | 93.1     | 46.8                | 36.8     | 49.9                         | 89.2     |
| Kular <i>et al.</i> <sup>[17]</sup>      | 1                        | 81                   | 92       | 74                  | 76       | 72                           | 90       |
| Lee <i>et al.</i> <sup>[37]</sup>        | 5                        | 30                   | 60       | 35.3                | 75       | 35.3                         | 87.5     |
| Carbajo <i>et al.</i> <sup>[38]</sup>    | 6                        | –                    | 94       | –                   | 96       | –                            | 96       |
| Toksoy <i>et al.</i> <sup>[39]</sup>     | 1                        | 82                   | 87       | 54.5                | 58.8     | –                            | –        |
| Kansou <i>et al.</i> <sup>[40]</sup>     | 1                        | 90.5                 | 92.6     | 76.9                | 81       | –                            | –        |
| Schauer <i>et al.</i> <sup>[41]</sup>    | 1                        | 23.4                 | 30.6     | –                   | –        | –                            | –        |
| Musella <i>et al.</i> <sup>[42]</sup>    | 1                        | 60.9                 | 85.4     | –                   | –        | –                            | –        |
| Milone <i>et al.</i> <sup>[18]</sup>     | 1                        | 66.7                 | 87.5     | –                   | –        | –                            | –        |
| Lee <i>et al.</i> <sup>[43]</sup>        | 1                        | 47                   | 93       | –                   | –        | –                            | –        |

HTN, hypertension; LMGB, laparoscopic mini-gastric bypass; LSG, laparoscopic sleeve gastrectomy; T2DM, type 2 diabetes mellitus.

insulin, promotes the growth of beta ( $\beta$ ) cells by antiapoptotic effect, improves the action of this hormone, remission of T2DM after bariatric surgery is directly attributed to changes in gut hormones, indicating the influence of the anatomical arrangement of the gastrointestinal tract as the primary mediator in the control surgery on the disease, and the rearrangement of this anatomy promotes a simultaneous increase in insulin and adiponectin, in which a decrease in lipids occurs<sup>[48]</sup>.

One of the hypotheses about the effect of bariatric surgery on type 2 diabetes is the anti-incretin effect theory, which hypothesizes that there is a regulating or balancing mechanism called the anti-incretin system, which is responsible for reducing insulin secretion as well as its effect and reducing the growth of beta ( $\beta$ ) cells, and that the change that promotes the increase of anti-incretin. It may cause insulin resistance and reduce the secretion of this protein, so the defect in the production of anti-incretins, which may occur in bariatric surgery, would lead to instability of the system, and thus amelioration or remission of the disease<sup>[49]</sup>.

Another theory suggests that the rapid transport of digested materials reduces their absorption in the distal part of the intestine, which increases the secretion of GLP-1, and although the mechanism of this effect is not yet fully known, it can be linked directly to the transport of nutrients apart from the secretion of known intestinal hormones<sup>[49,50]</sup>.

The HTN improvement and remission rate in the LMGB group (52.9, 41.4%) was greater than in the LSG group (47.5, 39%). Several studies reported similar results<sup>[17,30–36]</sup> where the HTN remission rate in the LMGB/MGB group (36.8–100%) was greater than in the LSG/SG group (35.3–78.3%) (Table 4).

One of the hypotheses about the effect of bariatric surgery on arterial tension, includes a decrease in the inflammatory response with improved insulin resistance can reduce arterial stiffness and sodium reabsorption and thus lead to the normalization of blood pressure levels, and patients with central obesity have an increased activation of the renin system – angiotensin-aldosterone, which may also return to normal after surgery.

A possible effect of GLP-1 on the sympathetic nervous system has been described, wherein an increase in digestive hormones such as peptide YY and GLP-1 can play an important role due to its effect on the digestive system along with a diuretic effect, as well as changes in adipokines and other inflammatory cytokines have a role. Moreover, as insulin sensitivity increases, levels of C-reactive protein and interleukin-6 decrease, thus relieving adipocyte inflammation and thus preventing constriction of blood vessels<sup>[51]</sup>.

All dyslipidemia patients have benefited from surgery, as the dyslipidemia improvement rate was greater in the LSG group, while the dyslipidemia remission rate was greater in LMGB group. Several studies have reached similar results<sup>[17,30–36]</sup>, where the dyslipidemia remission rate was greater in the LMGB/MGB group (29.8–100%) than in the LSG/SG group (14.2–72%) (Table 4).

The LMGB technique's superiority on the LSG technique in the occurrence of the incidence of the dyslipidemia remission rate may be due to fat malabsorption in addition to its having partial restrictive effects.

### Limitations

This study has some limitations, as it was cross-sectional study, so the level of evidence provided may not be as strong as that of other well designed studies like cross-sectional studies. Another

limitation of this study is the relatively low follow-up rate (12 months).

### Conclusions

In this study, we found that the LMGB technique was more effective than the LSG technique in controlling cardiovascular risk factors of obesity, T2DM, HTN, and dyslipidemia.

### Ethical approval

Ethical approval for this study (Ethical Committee No. 1256) was provided by the Scientific Research Ethics Committee in the Faculty of Medicine in Damascus University, Damascus, The Syrian Arab Republic on 10 April 2019.

### Consent

Informed consent from all participants was obtained after clear explanation about the purpose of the study, and copies of the written consent are available on request. Confidentiality and privacy of data were maintained. Written informed consent was obtained from the participants for publication and any accompanying images. A copy of the written consent is available for review by the Editor-in-Chief of this journal on request.

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### Author contribution

W.B.A.: corresponding author, contributed in study concept and design, data collection, and writing the paper; A.G.A.S.: contributed in supervising and reviewing the paper; Y.K.: contributed in co-supervising and reviewing the paper. All authors revised the final version of the manuscript critically and gave the final approval.

### Conflicts of interest disclosure

None of the authors have any competing interests. The authors alone are responsible for the content and the writing of the article. No conflict of interest is declared.

### Research registration unique identifying number

1. Registry used: <https://www.researchregistry.com/>.
2. Unique identifying number or registration ID: researchregistry-9080.
3. Hyperlink to your specific registration (must be publicly accessible and will be checked): <https://www.researchregistry.com/browse-the-registry#home/registrationdetails/6470aa49ec5650027c0be57/>.



## Guarantor

Abdul Ghani Al Shalabi and Younes Kabalan.

## Data availability statement

All data related to this paper's conclusion are available and stored by the authors. All data can be made available by the corresponding author upon a reasonable request.

## Provenance and peer review

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