Bariatric surgery and its role in the management of metabolic syndrome

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Background
Obesity has become a worldwide pandemic health problem, and morbid obesity leads to high rate of complications associated with metabolic syndrome, including type 2 diabetes mellitus (DM), hypertension, and hyperlipidemia. Bariatric procedures have become a main therapeutic option allowing improved diabetes, hypertension, and hyperlipidemia control in most patients

Patients and methods
A prospective study which was done between December 2015 and December 2017, this randomized study included 120 obese patients with metabolic syndrome who were divided into two groups: group 1 included 60 patients who were treated by laparoscopic sleeve gastrectomy (SG). Group 2 included 60 patients who were treated by laparoscopic minigastric bypass (MGB). The outcome for weight loss, DM control, blood pressure control, and hyperlipidemia were assessed and compared.

Results
A total of 120 patients were included in the study. The average age was 43.7 years and majority of them were women (80%). In the SG group: 40 (66.7%) patients were resolved (glycosylated hemoglobin<6.5% with no postoperative diabetic medication) from DM and 16 (26.7%) patients showed improvement. As regards hypertension 22 (55%) patients were resolved (no antihypertensive medications). As regards hyperlipidemia, 20 (41.6%) patients were resolved. In the MGB group: 48 (80%) patients were resolved (glycosylated hemoglobin<6.5% with no postoperative diabetic medication) from DM and 12 (20%) patients showed improvement. As regards hypertension 26 (59%) patients were resolved (no antihypertensive medications). As regards hyperlipidemia 30 (62.5%) patients were resolved. In comparison the MGB group has a statistically significant better effect in improvement of DM in early 6 months, and better outcome after 12 months but is not statistically significant.

Conclusion
SG and MGB are highly effective in the control of diabetes, hypertension, and hyperlipidemia but MGB has better and earlier effect than SG in diabetes remission.

Keywords:
diabetes mellitus, gastric sleeve, hyperlipidemia, hypertension, metabolic syndrome, minigastric bypass

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Introduction

Obesity has become a worldwide pandemic health problem, and morbid obesity leads to high rate of complications associated with metabolic syndrome (MetS), including type 2 diabetes mellitus (T2DM), hypertension, and hyperlipidemia. Bariatric surgery is not only a weight loss procedure but also can reverse most of obesity-related morbidities including diabetes mellitus (DM) in most of the cases [1].

The term MetS, first coined by Haller and Hanefeld [2], is characterized as a combination of underlying risk factors that – when occurring together – culminate in adverse outcomes, including T2DM, cardiovascular disease [3], and thus an ~1.6-fold increase in mortality [4].

The syndrome itself has had a variety of names, such as the insulin resistance syndrome, deadly quartet, syndrome X, syndrome X plus, among others.

Bariatric procedures have become the main therapeutic option allowing improved diabetes control in most patients. As suggested by the International Diabetes Federation (IDF), the achievable goal of bariatric surgery, a BMI reduction of 5 corresponds to a T2DM reduction of 33% [5].

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According to IDF, improvement in metabolic state may be defined as the lowering of glycosylated hemoglobin (HbA1c) by less than 20%, low-density lipoprotein (LDL) less than 2.3 mmol/l, and blood pressure less than 135/85 mmHg with reduced medication from the preoperative state [5].

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 biliopancreatic diversion with or without duodenal switch and the Roux-en-Y gastric bypass [6].

Conversely, classic restrictive procedures such as laparoscopic sleeve gastrectomy (LSG), although effective in weight loss, seem to provide different results on T2DM remission. The minigastric bypass (MGB) or one anastomosis gastric bypass originated by Rutledge [7] is a technique consisting of a simplified version of Roux-en-Y gastric bypass. Different authors have reported excellent results in weight loss and remission of T2DM.

Some theories could help to explain the mechanisms behind DM remission after bariatric surgeries other than weight loss. Hind gut and foregut hypotheses are the most frequently discussed. The hind gut hypothesis suggests that the fast arrival of foods to the end of the gastrointestinal tract improves the release of glucagon-like peptide 1 and peptide YY which enhances carbohydrate metabolism [8].

According to the foregut hypothesis, exclusion of the foregut from the passage of nutrients may suppress the production of anti-insulin hormones [9].

Furthermore, resection of a large part of the stomach leads to reduction of circulating ghrelin levels, thereby decreasing its obesogenic and diabetogenic properties [10].

Regardless of the details of each specific definition, it is generally accepted by all groups that the prevalence of MetS is increasing, in accordance with increasing BMI and age [11].

It was reported that the worldwide prevalence of MetS to be between 10 and 84% depending on the ethnicity, age, sex, and race of the population [12], whereas the IDF estimates that one-quarter of the world's population has MetS [13]. According to Pal and Ellis [14], 20% of adults in the western world have MetS.

In Egypt the prevalence of MetS is 20.6% (10.8% in men and 30.4 in women) and that of obesity is 25.6 and 26.8%, respectively [15].

Patients and methods

Objective

The main purpose of our trial is to define the role of LSG and laparoscopic minigastric bypass (LMGB) in the management of MetS.

Ethical and administrative information

A special informed consent was explained and signed by all patients. All patients accepted the anonymous form of publication for scientific purposes. We declared that there would not be any communication of personal data to third parties, to respect patients' privacy.

In this randomized trial, we decided to blind our data analyst to avoid any possible error or bias.

Indications, inclusion, and exclusion criteria

Between December 2015 and December 2017, 120 constitutive patients were enrolled in the study. Each patient was evaluated by a multidisciplinary team before the surgery. The indication for bariatric surgery procedure was given following the recommended indications of the International Federation for the Surgery of Obesity. For the bariatric surgeon, the indications were chronic morbid obesity with a BMI of at least 35 kg/m^2 with associated comorbidities related to the MetS, the failure of conservative treatment, and patient age between 16 and 65 years. All patients underwent preoperative ultrasound to determine the degree of hepatomegaly.

All patients that accepted the research study prospective and the risks/benefits of having bariatric surgery intervention for the management of MetS. The study included 120 obese patients with MetS who were divided into two groups:

(1) Group 1: (60 patients) treated by LSG.
(2) Group 2: (60 patients) treated by LMGB.

All patients have MetS with obesity (BMI>35), DM (HbA1c>6.5) with one or both of these criteria: (i) hypertension (systolic blood pressure>130 and diastolic blood pressure>85), (ii) hyperlipidemia [triglycerides (TGs)>150 mg/dl and total cholesterol>200 mg/dl, high-density lipoprotein (HDL)<40 mg/dl].

The patients who were excluded from the study are those who have endocrine abnormalities, for example,

hypothyroidism, Cushing syndrome, previous bariatric operations, major upper abdominal surgery, age below 16 years or more than 65 years, pregnant or lactating women, patients with contraindications for insufflation as those with severe cardiovascular or severe restrictive respiratory diseases and patients with major psychiatric illness.

We determined the preoperative patient characteristics for each group including age, sex, family history of DM, BMI loss, type of medication, duration of DM, and preoperative status of DM (better control if HbA1c<8.5% and no history of hyperglycemic complication and less control if HbA1c more than 8.5% with repeated emergency department visits for control of hyperglycemia). Also, the presence of hypertension and/or hyperlipidemia was assessed.

According to guidelines of the American Diabetes Association, the status of glucose metabolism is defined as:

(1) Normal glucose tolerance when fasting blood sugar (FBS) level less than 110 mg/dl.
(2) Impaired glucose tolerance when FBS was 110–125 mg/dl.
(3) DM when FBS was more than 126 mg/dl.

The American College of Endocrinology recommended an HbA1c level less than 6.5% as a target for diabetes control.

Outcomes assessment

Weight loss depending on the change in BMI which was measured at the initial screening on the day of surgery, 1 week at stitch removal, and at 1, 3, 6, and 12 months after surgery.

Intraoperative and postoperative complications (early or late) were recorded for each operation.

Assessment of diabetes mellitus

DM control was assessed by measurement of HbA1c at 3, 6, and 12 months and FBS at 1, 3, 6, and 12 months with follow up of changes in dose or discontinuation of antidiabetic medications. The outcome of each group [sleeve gastrectomy (SG) and MGB] was considered either resolved, improved, or unchanged. Resolved if HbA1c less than 6.5% and FBS less than 126 mg/dl with no postoperative diabetic medication. Improved if HbA1c and FBS levels decreased but still above the endpoint range (6.5 and 126 mg/dl, respectively) but with no postoperative diabetic medication. DM was considered unchanged if no improvement in HbA1c and FBS with still on postoperative medication.

Assessment of hypertension

Hypertension control was assessed by measurement of blood pressure at 1, 3, 6, and 12 months with follow up of changes or discontinuation of antihypertensive medications. Remission of hypertension (systolic blood pressure<130 and diastolic blood pressure<85 done by three readings over two visits) and stopping the antihypertensive medications, Improvement is by decreasing the number or dose of antihypertensive with maintaining a controlled blood pressure. No change if there is no improvement in blood pressure and inability to decrease the dose or number of antihypertensive medications.

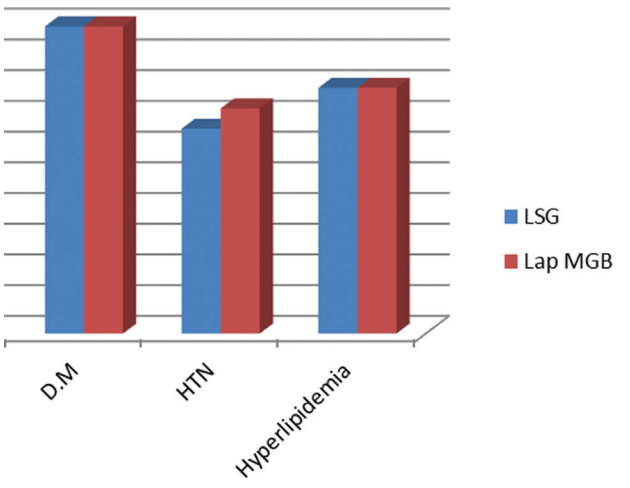
Assessment of hyperlipidemia

Hyperlipidemia control was assessed by evaluation of the lipid profile at 1, 3, 6, and 12 months. Remission of hyperlipidemia (TGs<150 mg/dl and total cholesterol<200 mg/dl, HDL>40 mg/dl). Improvement if the levels decrease but still above normal range or only one of them returns to normal; no improvement if there are no changes in the preoperative values.

Results

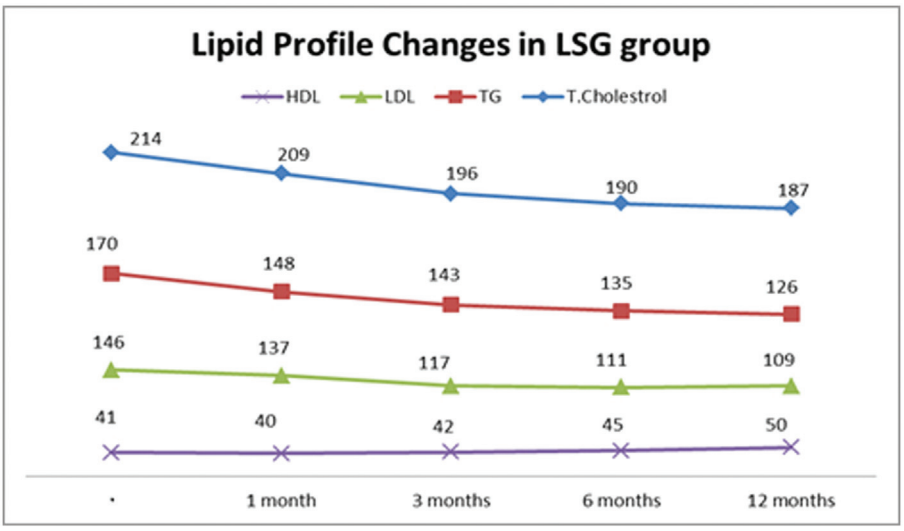
In total, 120 patients were enrolled in our study (60 patients underwent SG, 60 underwent MGB) (Figs 1–3).

Figure 1



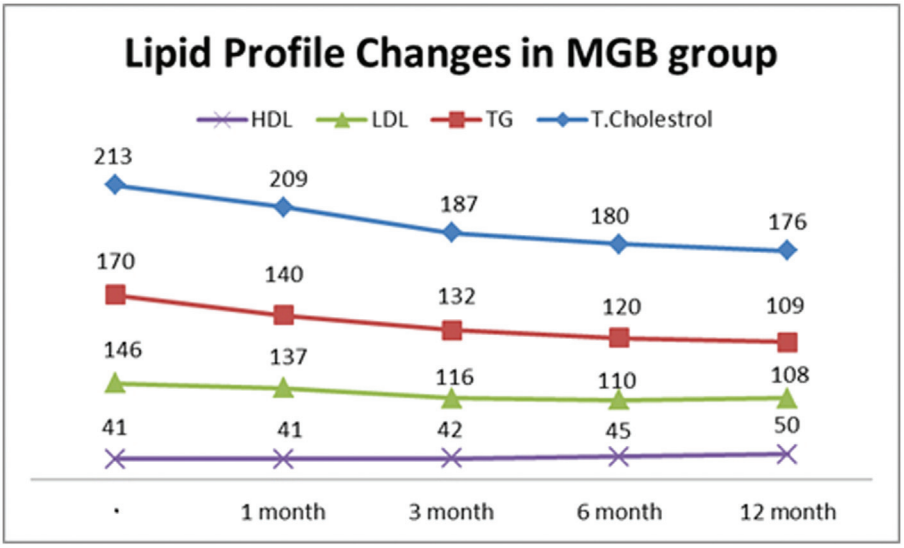
Distribution of the metabolic syndrome criteria among the two study groups. DM, diabetes mellitus; HTN, hypertension; LSG, laparoscopic sleeve gastrectomy; MGB, minigastric bypass.

Figure 2



Changes in the components of lipid profile of study group 1 within a year. LDL, low-density lipoprotein; HDL, high-density lipoprotein; LSG, laparoscopic sleeve gastrectomy; TG, triglyceride; T.Cholesterol, total cholesterol.

Figure 3



Changes in the component of lipid profile of study group 2 (MGB) within a year. LDL, low-density lipoprotein; HDL, high-density lipoprotein; MGB, minigastric bypass; TG, triglyceride; T.Cholesterol, total cholesterol.

Demographic and preoperative data in all sample patients

As regards all sample patients (120 obese patients with MetS), the age group ranged between 22 and 55 years with a mean±SD of 37.88±9.52 years. The group BMI ranged between 37 and 72 kg/m^2 with a mean±SD of 52.42±9.45 kg/m^2. Of the 120 patients, 76 (63.3%) patients were women and 44 (36.7%) patients were men.

As regards the duration of diabetes 68 (56.7%) cases were diabetic for less than 5 years and 52 (43.3%) cases for more than 5 years.

Family history for diabetes was positive in 80 (66.7%) patients and negative in 40 (33.3%) patients. As regards preoperative status of diabetes, 80 (66.7%) patients had better diabetes control with HbA1c less than 8.5% and no history of hyperglycemic complication, whereas 40 (33.3%) patients had less diabetes control with HbA1c more than 8.5% and with repeated emergency department visits for control of hyperglycemia.

As regards the type of diabetes medication, 36 (30%) patients were on insulin, whereas 84 (70%) patients on oral hypoglycemic medication.

Table 1 Comparison between group 1 (sleeve gastrectomy) and group 2 (minigastric bypass) as regards personal characteristics

	Groups [*n* (%)]		*P* value	Significance
	Sleeve gastrectomy	Minigastric bypass		
Age (mean±SD)	37.73±9.35	37.47±9.05	0.911[a]	NS
Sex				
Male	20 (33.3)	24 (40.0)	0.592[b]	NS
Female	40 (66.7)	36 (60.0)		
Family history				
Negative	24 (40.0)	16 (26.7)	0.273[b]	NS
Positive	36 (60.0)	44 (73.3)		

[a]Student's *t*-test. [b]χ^2-test.

Table 2 Comparison between group 1 (sleeve gastrectomy) and group 2 (minigastric bypass) as regards biochemical characteristics

	Groups (mean±SD)		*P* value	Significance
	Sleeve gastrectomy	Minigastric bypass		
C-peptide	3.77±1.25	4.13±1.37	0.549[a]	NS
BMI baseline	51.93±9.78	52.33±9.41	0.421[a]	NS
FBS baseline	145.27±12.78	149.67±12.27	0.514[a]	NS
HbA1c baseline	8.21±0.88	8.10±0.92	0.326[a]	NS
Systolic blood Pressure	145.7±10.7	143.5±11.7	0.99[a]	NS
Diastolic blood Pressure	86.3±8.9	90.4±8.6	0.97	NS

FBS, fasting blood sugar; HbA1c, glycosylated hemoglobin. [a]Student's *t*-test.

Table 3 Comparison between group 1 (sleeve gastrectomy) and group 2 (minigastric bypass) as regards medical characteristics

	Groups [*n* (%)]		*P* value	Significance
	Sleeve gastrectomy	Minigastric bypass		
Duration of DM (years)				
<5	36 (60)	32 (53.3)	0.593	NS
>5	24 (40)	28 (46.7)		
Preoperative medication				
OHG	44 (73.3)	40 (66.7)	0.573	NS
Insulin	16 (26.7)	20 (33.3)		
Status of DM (according to baseline HbA1c)				
Less control>8.5%	20 (33.3)	20 (33.3)	1.0	NS
Better control<8.5%	40 (66.7)	40 (66.7)		
C-peptide (ng/ml)				
<3	12 (20.0)	16 (26.7)	0.542	NS
>3	48 (80.0)	44 (73.3)		
Hypertension	40	44	0.832	NS
On medications	26	34	0.765	NS
Hyperlipidemia	48	48	1	NS

DM, diabetes mellitus; HbA1c, glycosylated hemoglobin; OHG, oral hypoglycemic.

The preoperative HbA1c ranged between 6.8 and 10% with a mean±SD of 8.16±0.85%. The preoperative C-peptide ranged between 1.5 and 6.9 ng/ml with a mean ±SD of 3.92±1.10 ng/ml with C-peptide more than 3 ng/ml being present in 92 (76.7%) patients, whereas C-peptide less than 3 ng/ml being present in 28 (23.3%) patients.

As regards hypertension, 84 (70%) patients were hypertensive and 60 (71%) of them were on antihypertensive medication.

The preoperative systolic blood pressure ranges from 120 to 160 with mean±SD of 144.6±11.14. The diastolic blood pressure ranges from 70 to 110 with mean±SD of 88.5±8.9.

As regards hyperlipidemia, 96 (80%) patients suffered from hyperlipidemia (abnormal lipid profile).

Comparison of demographic and preoperative data between the two groups (Tables 1–3).

Postoperative data

Obesity

(1) Group 1 (SG):
The mean BMI at baseline was 51.93±9.78 kg/m^2 and had decreased to at 1 month and to 44 ±8.49 kg/m^2 at 3 months and to 37.73±6.92 kg/m^2 at 6 months and finally to 33.47±5.69 kg/m^2 at 12 months with the final BMI loss being 18.47 ±5.14 kg/m^2.
(2) Group 2 (MGB):
The mean BMI at baseline was 51.53±9.41 kg/m^2 and had decreased to 43.93±7.94 kg/m^2 at 3 months and to 36.73±4.83 kg/m^2 at 6 months and finally to 31.87±3.66 kg/m^2 at 12 months with the final BMI loss being 19.67±7.17 kg/m^2 (Table 4).

Diabetes mellitus

(1) Group 1 (SG):
   (a) The mean FBS at baseline was 145.27 ±12.78 mg/dl and had decreased to 132.47 ±11.31 mg/dl at 3 months and to 124.20 ±10.99 mg/dl at 6 months and finally to 115.33±13.79 mg/dl at 12 months with the final FBS decrease being 29.93 ±12.84 mg/dl.
   (b) The mean HbA1c at baseline was 8.21±0.88% and had decreased to 7.35±0.81% at 3 months and to 6.70±0.71% at 6 months and finally to 6.20±0.73% at 12 months with the final HbA1c decrease being 2.01±0.59%.
   (c) The final outcome was:
      (1) Improved cases of DM (improvement in both HbA1c and FBS but still above 6.5% for HbA1c and above 126 mg/dl for FBS) was 16 (26.7%) cases.
      (2) Resolved cases (HbA1c<6.5% and FBS<126 mg/dl with no postoperative diabetes medication) was 40 (66.7%) cases with the early resolved cases (at 6 months) being 12 (20%) cases.
      (3) No change cases (no improvement in HbA1c and FBS with still on postoperative diabetes medication) was four (6.7%) cases.
(4) Group 2 (MGB):
   (a) The mean FBS at baseline was 149.67 ±12.27 mg/dl and had decreased to 135.47 ±9.99 mg/dl at 3 months and to 125.07 ±10.66 mg/dl at 6 months and finally to 111.87±12.05 mg/dl at 12 months with the final FBS decrease was 37.80 ±6.41 mg/dl.
   (b) The mean HbA1c at baseline was 8.10±0.92% and had decreased to 6.84±0.76% at 3 months and to 6.21±0.71% at 6 months and finally to 5.77±0.67% at 12 months with the final HbA1c decrease being 2.33±0.48%.
   (c) The final outcome was:
      (1) Improved cases of DM (improvement in both HbA1c and FBS but still >6.5% for HbA1c and >126 mg/dl for FBS) was 12 (20%) cases.
      (2) Resolved cases (HbA1c<6.5 and FBS<126 mg/dl with no postoperative diabetic medication) was 48 (80%) cases with the early resolved cases (at 6 months) being 28 (46.7%) cases.
      (3) No change cases (no improvement in HbA1c and FBS with still on postoperative diabetic medication) was 0 (Table 5).

Hypertension

(1) Group 1 (SG):
   (a) The mean systolic blood pressure preoperative was 145.79±10.71, which decreased to 140.26 ±11.11 at 1 month, then to 135.53±9.7 at 3 months, then to 132.89±10.18 at 6 months, and then to 130.79±9.32 by the end of the first year.
   (b) The mean preoperative diastolic blood pressure was 90.48±8.65 which improved to be 86.19±5.9 after 1 month, 83.10±4.6 after 3 months, 81.67±5.08 after 6 months, and 79.76 ±3.35 after 1 year.

Table 4 Comparison between groups 1 and 2 as regards BMI at baseline, at follow-up, and overall BMI loss

	Groups (mean±SD)		*P* value[a]	Significance
	Sleeve gastrectomy	Minigastric bypass		
BMI baseline	51.93±9.78	51.53±9.41	0.872	NS
BMI 1 month	48.2±8.8	48.3±8.5	0.924	NS
BMI 3 months	44.00±8.49	43.93±7.94	0.975	NS
BMI 6 months	37.73±6.92	36.73±4.83	0.519	NS
BMI 12 months	33.47±5.69	31.87±3.66	0.200	NS
Total BMI loss	18.47±5.14	19.67±7.17	0.459	NS

[a]Student's *t*-test.

Table 5 Comparison between groups 1 and 2 as regards glycosylated hemoglobin at baseline, at follow-up, and overall glycosylated hemoglobin change

	Groups (mean±SD)		*P* value[a]	Significance
	Sleeve gastrectomy	Minigastric bypass		
HbA1c baseline	8.21±0.88	8.10±0.92	0.648	NS
HbA1c 3 months	7.35±0.81	6.84±0.76	0.014	S
HbA1c 6 months	6.70±0.71	6.21±0.71	0.009	HS
HbA1c 12 months	6.20±0.73	5.77±0.67	0.022	S
Total HbA1c change	2.01±0.59	2.33±0.48	0.024	S

HbA1c, glycosylated hemoglobin; HS, highly significant; S, significant. [a]Student's *t*-test.

Table 6 Comparison of final outcome of hypertension between the two study groups

	LSG (*n*=40) [*n* (%)]	MGB (*n*=44) [*n* (%)]	Test value	*P* value	Significance
Resolved	22 (55)	26 (59)	0.306	0.858	NS
Improved	12 (30)	10 (23)			
No change	6 (15)	8 (18)			

LSG, laparoscopic sleeve gastrectomy; MGB, minigastric bypass.

(c) As regards antihypertensive medications, from the preoperative 40 hypertensive patients, 12 (30%) were on no medications (first diagnosis hypertension), 16 (40%) patients were on one medication, and 12 (30%) patients were on two medications; by the end of our study, 22 patients were on no more medications for blood pressure, 16 were controlled on one drug, and only two patients stayed on two medications.

(d) The final outcome was:
   (1) Resolved cases (control of blood pressure without any antihypertensive medications) were 22 (55%) cases.
   (2) Improved cases of HTN (control of blood pressure by decreasing the dose or the number of preoperative medications) were 12 (30%) cases.
   (3) No change cases (control of blood pressure on the same preoperative medications without decreasing the number or the doses) were six (15%) cases.

(4) Group 2 (MGB):
   (a) The mean systolic blood pressure preoperative was 143.33±11.44 which decreased to 138 ±9.28 after 1 month, then to 133.10±8.73 after 3 months, then to 129.76±7.98 after 6 months and then to 128.33±7.64 after 1 year.
   (b) The mean preoperative diastolic blood pressure was 86.32±8.95 which improved to 84.47±7.62 after 1 month, 81.05±5.91 after 3 months, 78.68±4.96 after 6 months, and 76.58 ±6.25 after 1 year.
   (c) As regard antihypertensive medications, from the preoperative 22 hypertensive patients, four were on no medications (first diagnosis hypertension); 12 patients were on one medication and six patients were on two medications, by the end of our study, 13 patients were on no more medications for the blood pressure, eight were controlled on one drug, and only one patient stayed on two medications.
   (d) The final outcome in hypertension control was:
      (1) Resolved cases (control of blood pressure without any antihypertensive medications) were 26 (59%) cases.
      (2) Improved cases of hypertension (control of blood pressure by decreasing the dose or the number of preoperative medications) was 10 (23%) cases.
      (3) No change cases (control of blood pressure on the same preoperative medications without decreasing the number or the doses) were eight (18%) cases (Table 6).

Hyperlipidemia

(1) Group 1 (SG):
   (a) The mean preoperative TGs were 170.96 ±1.78 which improved to be 127.54±3.3 after 1 month, 118.54±1.86 after 3 months, 105.92±2.08 after 6 months, and 89.17±1.79 after 1 year.
   (b) The mean preoperative cholesterol level was 214.96± 3.46 which improved to be 209.79 ±4.31 after 1 month, 196.469±14.07 after 3 months, 190.67±18.32 after 6 months, and 187.38±18.64 after 1 year.
   (c) The mean preoperative LDL was 146.75±3.05 which decreased to 137.63±3.13 after 1

Table 7 Comparison between groups 1 and 2 as regards outcome at 6 months and at final assessment

	Groups [*n* (%)]		*P* value	Significance
	Sleeve gastrectomy	Minigastric bypass		
DM resolved at 6 months				
No	48 (80.0)	32 (53.3)	0.028[a]	S
Yes	12 (20.0)	28 (46.7)		
DM outcome				
No change	4 (6.7)	0 (0.0)	0.331[b]	NS
Improved	16 (26.7)	12 (20.0)		
Resolved	40 (66.7)	48 (80.0)		
Hypertension outcome				
No change	6 (15)	8 (18)	0.858[a]	NS
Improved	12 (30)	10 (23)		
Resolved	22 (55)	26 (59)		
Hyperlipidemia outcome				
No change	12 (25)	8 (16.5)	0.351[a]	NS
Improved	16 (33.5)	10 (21)		
Resolved	20 (41.5)	30 (62.5)		

DM, diabetes mellitus; S, significant. [a]χ^2-test. [b]Fisher's exact test.

month, 117.58±2.59 after 3 months, 111.54 ±2.89 after 6 months, and 109.33±3.03 after 1 year.

(d) The mean preoperative HDL was 41.29±0.86 which became 40.92±0.88 after 1 month, 42.92±1.35 after 3 months, 45.38±1.84 after 6 months, and 50.92±1.69 after 1 year.

(e) The final outcome was:
   (1) Resolved cases (lipid profile is back to normal in all parameters, total cholesterol<200 mg/dl, TG<150 mg/dl) were 20 (41.5%) cases.
   (2) Improved cases (lipid profile is improved in one or both parameters but still total cholesterol>200 mg/dl or TG>150 mg/dl or only one returns to normal) were 16 (33.5%) cases.
   (3) No change cases (lipid profile did not improve in both parameters) were 12 (25%) cases.

(4) Group 2 (MGB):
   (a) The mean preoperative TG was 170.96±1.78 which improved to 148.79.79±20.93 after 1 month, 143.29±23.71 after 3 months, 135.08. ±27.61 after 6 months, and 126.29±35 after 1 year.
   (b) The mean preoperative cholesterol level was 213.79±3.28 which improved to 209.04±3.29 after 1 month, 187.83±14.06 after 3 months, 180.58.±17.12 after 6 months, and 176.83 ±18.74 after 1 year.
   (c) The mean preoperative LDL was 146.17±2.3 which decreased to 137.71±3.69 after 1 month, 116.92±2 after 3 months, 110.79±1.93 after 6 months, and 108.5±2.06 after 1 year.
   (d) The mean preoperative HDL was 41±0.83 which became 40.79±0.88 after 1 month, 42.67±1.27 after 3 months, 45.29±1.71 after 6 months, and 50.96±1.52 after 1 year.
   (e) The final outcome was:
      (1) Resolved cases (lipid profile is back to normal in all parameters, total cholesterol<200 mg/dl, TG<150 mg/dl) was 30 (62.5%) cases.
      (2) Improved cases (lipid profile is improved in one or both parameters but still total cholesterol>200 mg/dl or TG>150 mg/dl or only one returns to normal) were 10 (21%) cases.
      (3) No change cases (lipid profile did not improve in both parameters) were eight (16.5%) cases (Table 7).

Discussion

The dramatic rise in the prevalence of MetS has become a major global health issue. The problem is complex and will require strategies at many levels to prevent, control, and manage. It is well known that obesity has a profound effect on tissue sensitivity to insulin and so leads to glucose intolerance, increased blood pressure, and abnormalities in lipid profile.

The aim of our study was to compare between MGB and SG in the control of parameters of MetS through serial postoperative follow up of BMI, HbA1c, FBS, blood pressure, and lipid profile. It is a prospective study which was done since December 2015 till December 2017. The study included 120 obese

patients, 60 of them underwent SG and the other 60 patients underwent MGB.

As regards BMI loss, in our study when comparing the mean BMI loss after 1 year between SG group and MGB group we found that the mean BMI loss was 18.47±5.14 kg/m^2 in SG, whereas it was more in MGB (19.67±7.17 kg/m^2); but this difference was statistically nonsignificant. These results were similar to the results of the study conducted by Milone *et al.* [16] (to compare between SG and MGB in diabetes remission after 1 year) in which, SG and MGB were associated with changes in BMI (20.33±4.48 vs. 19.19 ±4.42%) and also the difference between them was statistically nonsignificant (P=0.931).

Wang *et al.* [17] published their results on 423 consecutive patients (87 men and 336 women) who underwent LMGB for morbid obesity. The BMI decreased from 44.2 to 35.1, 31.9, and 29.2, at 3, 6, and 12 months, respectively, with total BMI loss after i year being 15 kg/m^2, whereas in our study the BMI decreased from 51.53 to 43.93, 36.73, and 31.87 at 3, 6, and 12 months, respectively, with the total BMI loss after 1 year being 19.67 (better than the study by Wang *et al.* [17]).

In the study done by Musella *et al.* [18], after SG, BMI decreased from basal 47.9 to 32.6 after 1 year with total BMI loss after 1 year being 15.3 kg/m^2 (less than in our study), whereas in the MGB group, BMI decreased from basal 50.8 to 29.2 after 1 year with the total BMI loss being 21.7 kg/m^2 (better than in our study).

As regards diabetes remission effect, MGB has a better effect than SG in diabetes remission detected by that the mean FBS drop after 1 year in MGB (37.80 ±6.41 mg/dl) was more than after SG (29.93 ±12.84 mg/dl) and this difference in drop was highly statistically significant (P<0.004).

The mean HbA1c drop after 1 year in MGB (2.33 ±0.48%) was more than in SG (2.01±0.59%) and this difference in drop was statistically significant (P<0.024).

So, complete resolution of diabetes occurred in MGB cases in 80% compared with 66.7% in SG cases at 12 months and cases with no remission in DM was 0% in MGB and 6.7% with SG.

Also, we found that the effect of MGB on diabetes resolution was faster and earlier than SG reflected by cases with early diabetes resolution at 6 months being 46.7% with MGB in comparison to 20% with SG.

The universal published data show results similar to our study. A retrospective study by Lee *et al.* [1] included 62 T2DM obese patients who underwent gastrointestinal surgery (laparoscopic gastric bypass, LMGB, and LSG). After 1 year the result was remission of T2DM achieved in 45 (72.5%) patients after these different operations. A comparison among three different operative methods has shown that a remission rate of T2DM was achieved in 84.8, 58.8, and 58.3% of patients for LMGB, laparoscopic adjustable gastric banding, and LSG, respectively. LMGB had the best remission effect on T2DM (85%) at 1 year after surgery compared with laparoscopic adjustable gastric banding and LSG [1]. The result of our study agreed with this study as both operations are effective in diabetes remission but MGB has better effect than SG.

Another study by Milone *et al.* [16] through a 3-year period (from January 2009 to December 2011) at the University of Naples 'Federico II' on was conducted on 53 patients diagnosed with obesity and diabetes. The patients were split into two groups according to the surgical intervention performed, SG and MGB [16]. They found that at the 12 months follow-up, 66.7% of patients who underwent SG achieved diabetes remission versus 87.5% of those who underwent MGB (P=0.220).

Regarding hypertension, in group 1 (SG) resolution of hypertension was 55%, improvement was 30%, and no change in hypertension status was 15%. In group 2 (MGB) resolution of hypertension was 59%, improvement was 23%, and no change in hypertension status was 18%, whereas comparing the two groups no statistical difference was found between both procedures.

Regarding hyperlipidemia, in group 1 (SG) resolution of hyperlipidemia was 41.5%, improvement was 33.5%, and no change in hyperlipidemia status was 25%. In group 2 (MGB) resolution of hyperlipidemia was 62.5%, improvement was 21%, and no change in hyperlipidemia status was 16.5%, while comparing the two groups.

Conclusion

Bariatric surgery (SG and MGB) is not only a weight-reducing surgery but a metabolic surgery which can cure most of the MetS and they are considered the most effective long-term treatment modality for type 2 diabetes in obese patients and with comparing between SG and MGB, our study suggests that both procedures

are highly effective in the control of diabetes, hypertension, and hyperlipidemia, but MGB has a better and earlier effect than SG in diabetes remission.

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There are no conflicts of interest.

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