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RESEARCH ARTICLE

Does laparoscopic gastric sleeve improve lipid profile in obese patients? A five-year retrospective study

Aysha Saqer Mustafa [1], *Zumin Shi* [2], *Marios Hadjicharalambous* [3], *Mohammad Mollazehi* [4], *Manar AlDweik* [5], *Ayat Alshaer* [6], *Usama ALAlami* [7], *Norshafarina Shari* [1*]

[1] School of Graduate, Postgraduate Centre, Management and Science University, MALAYSIA

[2] College of Health sciences, Human Nutrition Department, Qatar University, Doha 2713, QATAR

[3] Human Performance Laboratory, Department of Life Sciences, School of Life and health Sciences, University of Nicosia, CYPRUS

[4] College of Art and Science, Qatar University, Doha 2713, QATAR

[5] Women's Wellness and Research Center, Hamad Medical Corporation, Doha 3050, QATAR

[6] College of Physical Education, Qatar University, Doha 2713, QATAR

[7] School of Life Sciences; Manipal Academy of Higher Education, Dubai, UNITED ARAB EMIRATES

Correspondence:

Norshafarina Shari, Prof. Dr.

Address: School of Graduate, Postgraduate Centre, Management and Science University, MALAYSIA

Email: norshafarina@msu.edu.my

ABSTRACT

In Qatar, laparoscopic gastric sleeve (LGS) is a key surgical method for obesity treatment. This study assessed its impact on the lipid profiles of 863 obese patients, some with hyperlipidemia. Spanning five years (2015-2020), the research monitored metrics like total cholesterol (TC), triglyceride (TG), low-density lipoprotein cholesterol (LDL), and high-density lipoprotein cholesterol (HDL). Post-LGS, TC, and LDL levels decreased after three months, increased, and then significantly dropped from the 2nd to the 5th year. TG levels consistently declined over five years, while HDL saw a marked rise from six months to five years post-surgery. In conclusion, LGS positively influenced lipid profiles during certain post-operative periods.

Keywords: laparoscopic gastric sleeve, hyperlipidemia, cholesterol, LDL, triglyceride, HDL

INTRODUCTION

Obesity and overweight are currently considered as a pandemic that grows rapidly, particularly for the past five decades [1]. Obesity is one of the considerable common health interests in many countries. It is a widely known connected risk factor for many health problems. Approximately 20% of the adult population in Middle East and North Africa (MENA) Region is classified as obese [2]. World Health Organization (WHO) defines overweight as a body mass index (BMI)≥25 kg/m^2 and obesity as a BMI≥30 kg/m^2 [3, 4]. In this regard, Qatar is not an exception [5]. In 2006, world health survey reported that 16% of Qatari children were overweight based on BMI standard levels set by WHO [6]. Subsequently, in 2012, following the guidelines of WHO stepwise approach to surveillance, the national survey reported ~70% of the Qatari population to be overweight (BMI>25 kg/m^2) in which 41% of 2,384 participants (aged 18-64 years) were classified as obese (BMI≥30 kg/m^2), with observed greater obesity prevalence in women (43%) than in men (40%) [7]. A more recent 2021 analysis using a dataset of electronic medical records from primary healthcare clinics (n=176,170; age≥18 years) reported the prevalence of obesity as 33%. However, the report did not discriminate between Qatari nationals and non-Qatari resident populations [7]. Qatar has world's fifth highest obesity prevalence rate, which is 54.7% [8]. Obesity should be considered a chronic disease, especially in context of morbid obesity, and therapeutic approaches should be directed.

One of the comorbidities of obesity is dyslipidemia. Dyslipidemia is a polygenic condition caused by a combination of both genetic and environmental factors. A 64 hospitals study from the gulf region (Bahrain, Oman, Qatar, Kuwait, the UAE, and Yemen) dyslipidemia prevalence was higher in females than males (44% vs. 28%), respectively [9-11]. Likewise, the Saudi project for assessment of coronary events reported the prevalence of dyslipidemia to be 31% [12].

Obesity is often associated with a dyslipidemia, which is low high-density lipoprotein cholesterol (HDL) levels, high levels of small, dense low-density lipoprotein cholesterol (LDL) particles and hypertriglyceridemia [13]. Studies concluded that

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a minimum of 5%-10% body weight reduction has been linked to a marked reduction in the comorbidities of [14]. Management of obesity is complex and involves multiple variables, with sometimes limited efficacy of the conservative approach [15]. Studies showed the superiority of bariatric surgery (BS) versus nonsurgical treatment on treating obesity comorbidities [16].

BS is an effective intervention to achieve long-term marked weight reduction in patients with severe obesity. In addition, an improvement of obesity-related comorbidities such as dyslipidemia was observed after BS, leading to a lower risk for cardiovascular disease (CVD) and decreased morbidity and mortality. BS improves many health-related outcomes [17].

BS is in demand worldwide and is gaining much support and acceptance because of the continuous prevalence and rapid rise of obesity globally and in south and Southeast Asia [18]. Among morbidly obese adults and adolescents, BS has been associated with resolution of metabolic conditions [19]. BS is a group of surgeries, which are performed on stomach or intestine in order to treat obesity [20].

The most performed procedures are laparoscopic sleeve gastrectomy and laparoscopic gastric bypass, which comprise more than 80% of total bariatric surgeries performed globally [21]. Among these, sleeve gastrectomy is increasingly utilized for morbidly obese adults and adolescents and has been shown to be more effective than gastric banding for adults and adolescents [22].

The 5th edition of the International Federation for the Surgery of Obesity and Metabolic Disorders global registry report recorded over 800,000 BS procedures spanning 61 countries and 17 national registries from 2014 to 2019 [23]. Within MENA Region, characterized predominantly by Arab culture, there's a notable surge in BS procedures to combat obesity and metabolic disorders [24]. A local newspaper article from December 2019 highlighted the achievements of a single private hospital, established in 1998 and recognized as Center of Excellence in Metabolic and Bariatric Surgery (COEMBS) since 2015. This hospital, Al-Emadi Hospital, reported over 8,000 successful surgeries in just five years, averaging an impressive 133 surgeries per month, especially considering Qatar's 2021 population of 2.6 million.

Studies argued the superiority of some bariatric procedures versus others in their effectiveness [3]. The choice of the optimum BS procedure to improve lipid profiles of patients with obesity was debatable, and results showed diverse outcome regarding cholesterol, LDL, HDL, and triglyceride (TG) in each study [25-27].

Interpretation of the outcome of the lipid profile in many studies relied on different factors that might be associated with laparoscopic gastric sleeve (LGS) [28]. One of those factors is physical activity. It was evaluated the effect of physical activity of 50 patients who underwent LGS with 50% of the total patients complaining of hyperlipidemia on the lipid profile [29]. Spanish version of the modifiable physical activity questionnaire was distributed through personal interviews at two time points: before the operation as a baseline point, and after one year of LGS to determine the changes in lipid profile in these time points. The study concluded that adding a routine moderate physical activity as an associated factor to LGS had significant progress in all lipid profile measurements [29].

Age plays a pivotal role in the outcomes of LGS. A prospective study involving 35 adolescent patients, aged 12 to 19 years and diagnosed with morbid obesity, who underwent LGS was conducted. The findings indicated that LGS had a short-term beneficial effect on adolescents with obesity, leading to the resolution of comorbidities such as hyperlipidemia and hypertension, in addition to significant weight loss, as observed over a regular one-year follow-up [30].

The influence of different obesity classes on the efficacy of LGS in enhancing lipid profiles has been explored. In the United States, a study evaluated patients with severe obesity (n=1,002) over a 12-month follow-up period. It was observed that the effect of LGS on the lipid profile, with the exception of low-density lipoprotein, was favorable for patients during the rapid weight loss of 65% of the excess BMI [31]. The current study aimed to examine the effect of LGS on blood lipid profile for the patients who underwent LGS surgery in the state of Qatar.

MATERIALS & METHODS

Study Design

A community-based cross-sectional study was conducted among 863 patients with obesity (n=863: male=285 & female=578) aging 18 years and above; with or without hyperlipidemia, who underwent LGS operation, were evaluated for total cholesterol (TC), TG, LDL, HDL prior to LGS and are residents in the State of Qatar during a time period of five years (2015 to 2020). These individuals were selected based on meeting the selection criteria of having or not having dyslipidemia and undergone LGS BS. Collected data included gender, age, nationality, and lipids profile. Variables that are not included in this study were body weight, excess weight before operation, excess weight loss after operation. History of smoking; hyperlipidemia treatment records before and after the surgery; resected part from the stomach and the rest of the gastric volume. The study was conducted at Al-Emadi Hospital, in Qatar, which was accredited as the first center in Qatar of COEMBS, from The Surgical Review Corporation of the United States of America.

Inclusion & Exclusion

Several variables were excluded from the study, as they could have affected the outcome. These excluded variables included patient characteristics such as body weight (before or after the operation) and excess weight before the operation and excess weight loss after the operation, as these data were not extracted by SAGE software in the hospital's system. Patients with pregnancy and lactation were also excluded. In addition, patients were categorized as type-1 or type-2 diabetic mellitus and their smoking history, the duration of diabetes mellitus (DM) disease, antidiabetic treatment records, antihyperlipidemic treatment records, and iron supplement records before and after the surgery were also excluded. Moreover, complications of DM such as diabetic foot syndrome, retinopathy, neuropathy, nephropathy, microangiopathy, and macroangiopathy, were excluded from the study. Other variables such as the resected part from the stomach and the rest of the gastric volume, end-stage cardiac disease, end-stage renal disease, or end-stage cancer were also excluded from the study.

Methodology & Patient's Testing

The follow-up data of these patients were recorded in the medical record system of Al-Emadi Hospital in Qatar. The included variables in the study were patient characteristics such as sex, age, and nationality, blood lipid profile measured by mg/dl including TC, TG, LDL, HDL at baseline (prior to operation), and within (<three months; three-six months; six-12 months; two years, and ≥three years) of operation, as well as biochemical measurements including blood glucose: fasting blood sugar and glycated hemoglobin, iron profile comprises lab tests for the serum levels of: iron, total iron binding capacity, ferritin, and hemoglobin.

All data were extracted by IT department to guarantee the confidentiality of the patients through the system of the hospital data bank. Exemption form has been given by the Ministry of Public Health in Qatar, to get the required ethical approval for the study. No consent form from patients was required to be enrolled in the study or for future dissemination of the research findings.

Statistical Analysis

The descriptive statistics on patient's lipid profile were conducted by using the mean and standard error (SE). Generalized linear mixed models (GLMMs) were used to estimate fixed and random effects. One reason for using these models was that data of the current study was not normally distributed and involves repeated measures, since GLMMs can model autocorrelation. p-value of <0.05 was considered statistically significant. Statistical analysis was conducted by using STATA (version 17).

Table 1. Sample characteristics (n=863)

Sociodemographic characteristics	n (%)
Mean age (years): Mean ± standard error	32.7±10.7
Age (years)	
18-25	236 (27.3%)
26-40	432 (50.1%)
41-60	187 (21.7%)
<60	8 (0.9%)
Gender	
Male	285 (33.0%)
Female	578 (67.0%)
Nationality	
Non-Qatari	201 (23.3%)
Qatari	662 (76.7%)

RESULTS

Sample Characteristics

Socio-demographic information collected for the participants in this study included age, gender, and nationality. Age was classified into four categories: 18-25 years, 26-40 years, 41-60 years, and 60+ years. Patients' characteristics along with nationality are shown in **Table 1**.

Out of the 863 subjects included in the present study, 33.0% (285/863) were found to be males, whereas 57.8% (578/863) were females with a mean age of all studied subjects of (32.7±10.7 years), and the female-to-male ratio was 67:33. The majority of participants were between the ages of 26-40 years. Most participants were Qatari, with 76.7% of the sample, while the remaining 23.3% were non-Qatari.

Descriptive Statistics

Table 2 presents the mean values of serum cholesterol, LDL cholesterol, HDL cholesterol, and TG at different time points before and after LGS. Before surgery, the mean value of serum cholesterol was 191.82 mg/dl, which decreased to

Table 1. Mean values of lipid profile among patients underwent LGS

Biochemical parameters of lipid profile	Before operation	<3 months	3-6 months	6-12 month	2 years	≥3 years
Cholesterol (mg/dl)	191.82	172.14	197.2	188.26	187. 45	180.78
	(1.87)	(6.18)	(6.34)	(7.74)	(7.26)	(5.72)
LDL (mg/dl)	128.37	113.53	129.54	129.50	1.24.04	105.75
	(1.92)	(6.27)	(6.33)	(7.7)	(6.5)	(5.5)
HDL (mg/dl)	48.94	44.58	49.95	54.16	56.61	60.08
	(0.68)	(1.91)	(1.66)	(2.18)	(2.13)	(1.66)
TG (mg/dl)	139.45	105.85	94.92	77.24	65.15	82.18
	(5.37)	(18.22)	(20.51)	(22.05)	(18.04)	(15.86)

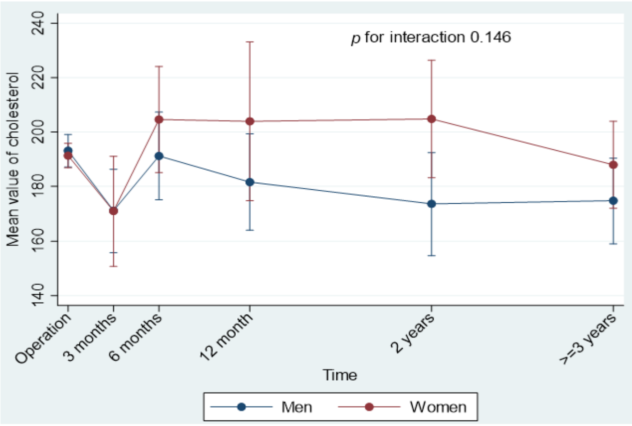

Figure 1. Mean concentration of cholesterol for both males & females versus operation & post-operation time (Source: Authors' own elaboration)

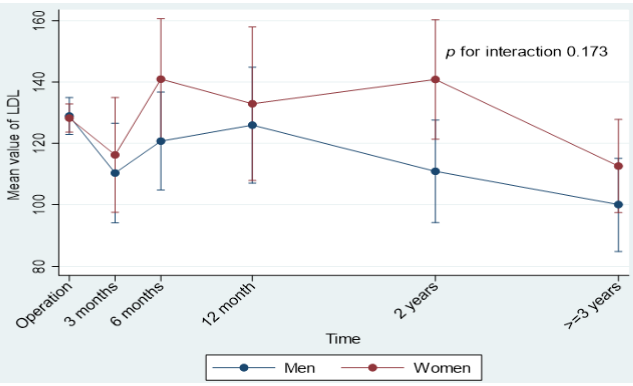

Figure 2. Mean concentration of LDL for both males & females versus operation & post-operation time (Source: Authors' own elaboration)

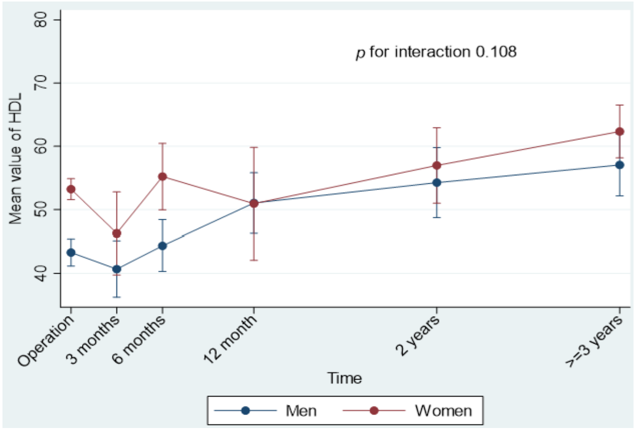

Figure 3. Mean concentration of HDL for both males & females versus operation & post-operation time (Source: Authors' own elaboration)

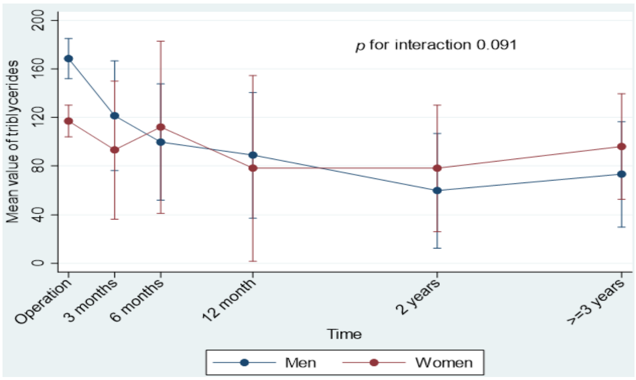

Figure 4. Mean concentration of TG for both males & females versus operation & post-operation time (Source: Authors' own elaboration)

172.14 mg/dl in the first three months post-surgery, then slightly increased to 197.2 mg/dl from three to six months post-surgery.

The mean values decreased slightly after six months, 12 months, two years, and more than two to five years post-surgery, to reach 188.26 mg/dl, 187.45 mg/dl, and 180.78 mg/dl, respectively (**Figure 1**).

The mean value of serum LDL before surgery was 128.37 mg/dl, which decreased to 113.53 mg/dl in the first three months post-surgery, then slightly increased to 129.54 mg/dl from three to six months post-surgery.

Mean values decreased after six months, 12 months, two years, and up to five years post-surgery, to reach 129.5 mg/dl, 124.04 mg/dl, and 105.75 mg/dl, respectively (**Figure 2**).

The mean values of TG decreased from 139.45 mg/dl before surgery to reach 82.18 mg/dl after more than two years post-surgery. The mean values of TG were less than the mean value of the operation day after three months, six months, 12 months, two years, and more than two to five years post-surgery, to reach 105.85 mg/dl, 94.92 mg/dl, 77.24 mg/dl, 65.15 mg/dl, and 82.18 mg/dl, respectively, showing an improvement in TG values after surgery (**Figure 3**).

The mean value of HDL before surgery was 48.94 mg/dl, which decreased to 44.58 mg/dl in the first three months post-surgery, then increased after three months, six months, 12 months, two years, and up to five years post-surgery, to reach 49.95 mg/dl, 54.16 mg/dl, 56.61 mg/dl, and 60.08 mg/dl, respectively, compared to the mean value of the operation day (**Figure 4**).

In summary, the descriptive statistics indicate an improvement in the patient's lipid profile after LGS surgery.

In **Table 3**, the results of GLMMs used in this study show that the serum cholesterol level decreased by 19.68 mg/dl in the first three months after the operation compared to the operation-day level, and this reduction was statistically significant (β=19.68, p=0.002). However, in the periods after the operation (three-six months, six-12 months, 12 months up to two years, two-five years), the difference in the level of serum cholesterol compared to the operation-day level changed by (+5.39, -3.56, -4.36, and -11.04) mg/dl, respectively, and these differences were statistically insignificant (p>0.05), as p-value were (0.401, 0.650, 0.554, and 0.060), respectively.

Table 3. Regression coefficients for blood lipids by time since operation adjusting for age & gender

	Cholesterol (mg/dl)		LDL (mg/dl)		HDL (mg/dl)		TG (mg/dl)	
	Coef. (95% CI)	**p**	**Coef. [95% CI]**	**p**	**Coef. [95% CI]**	**p**	**Coef. [95% CI]**	**p**
Time since operation								
Operation	0.00		0.00		0.00		0.00	
3 months	-19.68 (-32.10--7.25)	0.002	-14.84(-27.44--2.23)	0.021	-4.37 (-8.08--0.65)	0.021	-33.60 (-70.65-3.45)	0.075
6 months	5.39 (-7.19-17.97)	0.401	1.17 (-11.49-13.83)	0.856	1.01 (-2.18-4.21)	0.535	-44.53 (-85.95--3.11)	0.035
12 months	-3.56 (-18.94-11.81)	0.650	1.13(-14.23-16.48)	0.886	5.22 (0.93-9.50)	0.017	-62.21 (-106.5--17.88)	0.006
2 years	-4.36 (-18.82-10.09)	0.554	-4.33(-17.41-8.75)	0.517	7.66 (3.49-11.84)	<0.001	-74.30 (-111.0--37.51)	<0.001
≥3 years	-11.04 (-22.56-0.48)	0.060	-22.62(-33.85--11.40)	<0.001	11.14 (7.89-14.39)	<0.001	-57.27 (-90.02--24.51)	<0.001
Age (years)	0.52 (0.21-0.84)	0.001	0.28 (-0.04-0.59)	0.087	0.03 (-0.08-0.15)	0.580	1.16 (0.32-2.00)	0.007
Gender								
Male	0.00		0.00		0.00		0.00	
Female	1.37 (-5.58-8.31)	0.700	2.83 (-4.14-9.80)	0.426	9.02 (6.44-11.61)	<0.001	-36.86 (-55.50--18.22)	<0.001

Regarding LDL cholesterol, **Table 3** shows that during the first three months of operation, the level was 14.84 mg/dl less than the operation-day level, and this reduction was statistically significant (β=14.84, p=0.021). After (three-six months, six-12 months, 12 months, up to two years) postoperatively, the differences were statistically insignificant at the 5% level of significance (p-values were 0.856, 0.886, and 0.517, respectively). From two-five years postoperatively, the difference was statistically significant at the 5% level of significance (β=22.62, p<0.001).

Table 3 also shows the effects of LGS surgery on TGs. During the first three months after the operation, the difference in the level of TGs was less than the operation-day level by 33.6 mg/dl, which was statistically insignificant (β=33.6, p=0.075). After (three-six months, six-12 months, 12-24 months, two years, up to five years) postoperatively, the differences in the mean values were statistically significant at the 5% level of significance (p<0.05), as p-value were (0.035, 0.006, <0.001, and <0.001), respectively, and less than the operation-day level by (44.53, 62.21, 74.3, and 57.27) mg/dl, respectively. These results clearly show an improvement in TG levels after the surgery.

Furthermore, **Table 3** provides the results related to the effects of LGS surgery on patients' HDL cholesterol level. During the first three months of operation, the difference in patients' HDL cholesterol level was reduced by 4.37 mg/dl compared to the operation-day level, and this reduction was statistically significant at the 5% level of significance (β=4.37, p=0.021). From three-six months of operation, the difference in mean value was more by 1.01 mg/dl, and this difference was statistically insignificant at the 5% level of significance (β=1.01, p=0.535) in this period. In time periods later, after more than six months, 12 months, two years, up to five years postoperatively, the patients' HDL cholesterol level was (5.22, 7.66, and 11.14) mg/dl, respectively, higher than the operation-day level of HDL cholesterol. These values were statistically significant at the 5% level of significance (p<0.05), as (0.017, <0.001, and <0.001), respectively.

The results of GLMMs on lipid profile indicators indicate that laparoscopic gastric surgery leads to an improvement in patients' lipid profile, as demonstrated by a decrease in serum TGs and LDL cholesterol compared to the levels on the operation day, and an increase in HDL cholesterol. However, it should be noted that the improvement in serum cholesterol and LDL was not significant during most of the postoperative period.

Cholesterol, LDL, HDL, and TG levels at different time points regarding participants' gender and age is shown in **Table 4**. The relationship between gender and different time

Table 4. Mean values of lipid profile among patients that underwent LGS in concern to participants' gender & age

			Before operation	**<3 months**	**3-6 months**	**6-12 month**	**2 years**	**≥3 years**
Cholesterol, mg/dl	All cholesterol samples		191.82	172.14	197.2	188.26	187.45	180.78
			(1.87)	(6.18)	(6.34)	(7.74)	(7.26)	(5.72)
	Gender	Male	193.1	171.04	191.17	181.55	173.55	174.71
			(3.05)	(7.77)	(8.23)	(9.04)	(9.61)	(7.97)
		Female	191.29	170.89	204.59	203.92	204.8	187.92
			(2.29)	(10.26)	(9.96)	(14.93)	(11.03)	(8.17)
	Age	<35 years	112.98	84.93	92.85	88.02	91.02	94.45
			(3.00)	(10.70)	(11.16)	(10.44)	(8.79)	(8.39)
		≥35 year	110.47	88.41	80.10	85.34	80.44	81.11
			(3.2)	(8.13)	(7.37)	(7.65)	(6.78)	(6.96)

Table 4 (continued). Mean values of lipid profile among patients that underwent LGS in concern to participants' gender & age

			Before operation	<3 months	3-6 months	6-12 month	2 years	≥3 years
LDL, mg/dl	All LDL samples		128.37	113.53	129.54	129.50	124.04	105.75
			(1.92)	(6.27)	(6.33)	(7.7)	(6.5)	(5.5)
	Gender	Male	128.89	110.31	120.71	125.92	110.86	100.01
			(3.07)	(8.29)	(8.16)	(9.65)	(8.54)	(7.69)
		Female	128.24	116.21	140.94	132.91	140.83	112.56
			(2.36)	(9.56)	(10.07)	(12.79)	(9.94)	(7.76)
	Age	<35 years	112.98	84.93	92.85	88.02	91.02	94.45
			(3.00)	(10.70)	(11.16)	(10.44)	(8.79)	(8.39)
		≥35 year	110.47	88.41	80.10	85.34	80.44	81.11
			(3.2)	(8.13)	(7.37)	(7.65)	(6.78)	(6.96)
HDL, mg/dl	All HDL samples		48.94	44.58	49.95	54.16	56.61	60.08
			(0.68)	(1.91)	(1.66)	(2.18)	(2.13)	(1.66)
	Gender	Male	43.31	40.69	44.36	51.04	54.25	57.05
			(1.09)	(2.28)	(2.06)	(2.44)	(2.82)	(2.50)
		Female	53.22	46.27	55.22	50.93	56.98	62.34
			(0.85)	(3.33)	(2.68)	(4.53)	(3.05)	(2.13)
	Age	<35 years	112.98	84.93	92.85	88.02	91.02	94.45
			(3.00)	(10.70)	(11.16)	(10.44)	(8.79)	(8.39)
		≥35 year	110.47	88.41	80.10	85.34	80.44	81.11
			(3.2)	(8.13)	(7.37)	(7.65)	(6.78)	(6.96)
TG, mg/dl	All TG samples		139.45	105.85	94.92	77.24	65.15	82.18
			(5.37)	(18.22)	(20.51)	(22.05)	(18.04)	(15.86)
	Gender	Male	168.53	121.36	99.59	88.88	59.62	73.16
			(8.47)	(23.11)	(24.49)	(26.31)	(24.04)	(22.03)
		Female	116.97	93.19	112.03	78.12	78.07	95.94
			(6.68)	(28.95)	(36.15)	(38.96)	(26.49)	(22.22)
	Age	<35 years	112.98	84.93	92.85	88.02	91.02	94.45
			(3.00)	(10.70)	(11.16)	(10.44)	(8.79)	(8.39)
		≥35 year	110.47	88.41	80.10	85.34	80.44	81.11
			(3.2)	(8.13)	(7.37)	(7.65)	(6.78)	(6.96)

points for cholesterol was examined, and the mean values showed parallel values between male and female participants, indicating no significant interaction effect between gender and time.

The results are illustrated in **Figure 1**. p-value for the interaction effect was 0.146.

Similarly, **Table 4** also explored the relationship between age and different time points for cholesterol, and the mean values showed no significant interaction effect between age and time.

Figure 5 shows visual representation of results. p-value for interaction effect was 0.932. The analysis also revealed an insignificant effect between participant gender and serum cholesterol (β=1.37, p=0.700). But there was a positive relationship between participant age and serum cholesterol level (β=0.52, p=0.001). In terms of time variable, there was a significant decrease in cholesterol levels three months after operation (β=-19.68, p=0.002). But differences in cholesterol

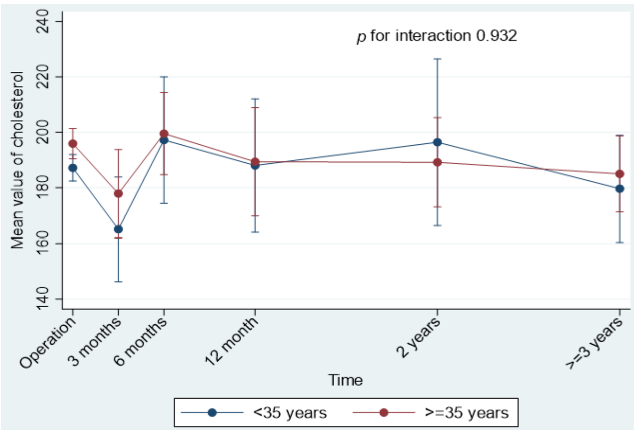

Figure 5. Mean concentration of cholesterol regarding age versus operation & post-operation (Source: Authors' own elaboration)

levels before operation and other time periods (six months, 12 months, two years, and ≥three years) were not significant (p>0.050). Similarly, **Table 4** provides LDL level in different time concerning participants' gender and age group.

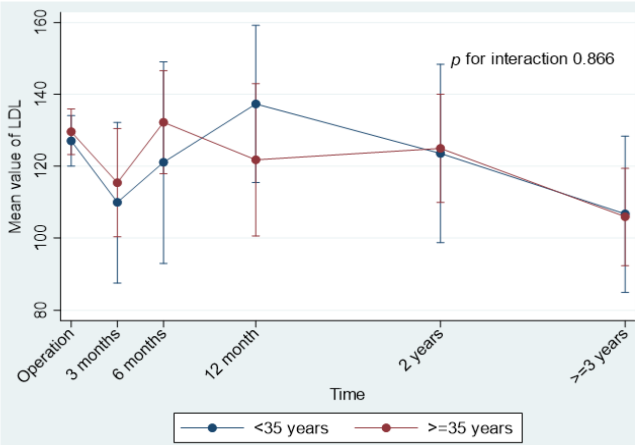

Figure 6. Mean concentration of LDL regarding age versus operation & post-operation (Source: Authors' own elaboration)

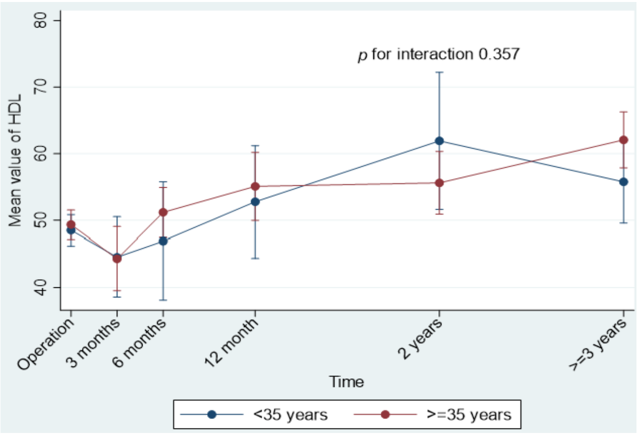

Figure 7. Mean concentration of HDL regarding age versus operation & post-operation (Source: Authors' own elaboration)

Table 4 examined relationship between gender and different time points for LDL (**Figure 6**). Means showed parallel values between males and females, indicating no significant interaction effect between gender and time. p-value for interaction effect was 0.108. Also, we showed relationship between age and time for LDL (**Figure 6**). Mean values showed no significant interaction effect between age and time. p-value for interaction effect was 0.866. Also, **Table 4** provides HDL level in different time concerning participants' gender and age group.

According to our analysis in **Table 4**, it shows the relationship between gender and different time points for HDL (**Figure 7**). Results of the current study show parallel values between male and female mean values, indicating that there is no interaction effect between gender and time. p-interaction is 0.108. Also, in **Table 4**, it shows the relationship between age and different time points for HDL (**Figure 7**). Mean values show values between participants <35 and >35 years old, indicating that there is no interaction effect between age and time. p-interaction is 0.0357.

TG level in different times concerning participants' gender and age group is also seen in **Table 4**. According to

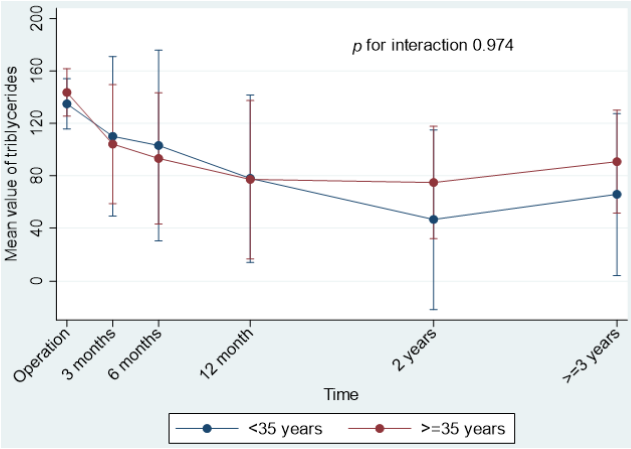

Figure 8. Mean concentration of TG regarding age versus operation & post-operation (Source: Authors' own elaboration)

Table 4, it is shown that the relationship between gender and different time points for TG (**Figure 8**). Mean values show the values between male and female mean values, indicating that there is no significant interaction effect between gender and time. p-interaction is 0.091. **Table 4** also shows the relationship between age and time for TG (**Figure 8**). Mean values show values between participants <35 and >35 years old, which indicates that there is no significant interaction effect between age and time. p-interaction is 0.974.

Figure 1-**Figure 4** shows the relationship between gender and post-operative time for all lipid profiles. In regard to cholesterol, LDL, TG, and HDL, the curves showed parallel values between males and females mean values, indicating that there is no interaction effect between gender and post-operative time for each mentioned variable.

Figure 5-**Figure 8** shows the relationship between age, operative and post-operative time for lipid profiles. According to cholesterol, LDL, TG, and HDL, the curves showed the parallel values between the age of patients less than 35 years old, and more than or equal 35 years old mean values, indicating that there is no interaction effect between age and time for each mentioned variable.

DISCUSSION

The present study has evaluated the effect of LGS on the changes in lipid profiles. The findings of this study indicated a statistically significant effect of LGS on various variables that may lead to improvements in multiple comorbidities. The results of the study demonstrated that LGS surgery has a positive impact on a patient's lipid profile. This is evident from the significant improvement in the serum levels of HDL and TG at most of the time points studied during the operation. However, the surgery did not result in significant improvements in serum cholesterol levels during the majority of the time points studied. Additionally, the serum level of LDL showed improvement only during the first and last time periods of the study.

The observations revealed a clear time-dependent effect of LGS surgery on patients in the postoperative period. Specifically, the time-dependent effect of the surgery on cholesterol was statistically significant at a 5% significance level during the first three months of the operation. However, from three to six months, six to 12 months, one to two years, and two to five years after the surgery, the differences in the mean values of cholesterol were statistically insignificant. With regards to LDL, the time-dependent effect of LGS surgery on LDL was statistically significant at a 5% significance level during the first three months of the operation. However, from three to six months, six to 12 months, and one to two years after the surgery, the differences in the mean values of LDL were statistically insignificant. From two to five years after the operation, the difference in the mean values of LDL was statistically significant. As for HDL, the time-dependent effect of LGS surgery on HDL was statistically significant at a 5% significance level during the first three months of the operation. After three to six months of the operation, the difference in the mean value of HDL was statistically insignificant. However, after six to 12 months, one to two years, and two to five years of the operation, the differences in the mean values of HDL were statistically significant. Regarding TGs, the time-dependent effect of LGS on TG was statistically insignificant at a 5% significance level during the first three months of the operation. However, from three to six months, six to 12 months, one to two years, and two to five years after the surgery, the differences in the mean values of TG were statistically significant.

LGS surgery has time-varying effects on patient's lipid profile [32, 33]. Research studies have demonstrated that a weight loss of at least 5% to 10% of body weight is linked to a significant reduction in comorbidities [34]. LGS surgery, through reducing body weight and BMI, improves lipid metabolism by increasing growth hormones that subsequently affect lipid metabolism, and reduces the risk of CVD. Studies have also found that for every kilogram of body weight loss, serum LDL levels decrease by 0.02 mmol/L, serum cholesterol levels decrease by 0.05 mmol/L, and serum HDL levels increase by 0.009 [35]. This highlights the significance of LGS surgery as an effective procedure for weight reduction.

Comparing the results of the current study with those of [35] during the same time point of the study, i.e., two years post-operation (from January 2018 to July 2020), the findings of [35] showed statistically significant changes (P-value <0.05) in TG and HDL. In contrast, there was an insignificant change in cholesterol and LDL during the same period of operation. The results of [35] are consistent with the results of the current study, which found insignificant changes in LDL and cholesterol. Additionally, the current study showed that lipid profile outcomes for participants after LGS surgery were influenced by age and gender. Concerning age, cholesterol and TG levels rose significantly with age, showing a positive correlation between participant age and serum cholesterol level. Conversely, the relationship between participants who underwent LGS and age for LDL and HDL was statistically insignificant. Regarding gender, TG results were significant (β=36.86, $p<0.001$), suggesting that women had lower TG levels than men, and in HDL (β=9.02, $p<0.001$), indicating that women had higher HDL levels than men. In contrast, cholesterol and LDL were not significantly influenced by gender. Both studies concur on the need for further research with extended follow-up. The similarities in the results of the current study and [35] might stem from comparable socio-demographic variables, such as samples from two GCC countries sharing the same ethnicity and environmental conditions. Differences in results between the current study and [35] might be due to gaps in patient history and the presence of other comorbidities affecting hyperlipidemia. Some researchers believe that all lipid profile parameters improve post-BS, especially sleeve gastrectomy, while others argue that only specific parameters show improvement. Therefore, the results of the current study are consistent with some studies and conflicting with others, including those referenced in [32, 36-38].

A systematic review and meta-analysis assessed the effects of various bariatric surgeries, including sleeve gastrectomy, in comparison to nonsurgical interventions on lipid profiles during the first postoperative year [36]. This study revealed enhancements in the lipid profile, with reductions in cholesterol, TG, and LDL levels and an increase in HDL levels relative to baseline measurements. The findings from this study are in line with the current research, which also documented improvements in TG and HDL within a similar period. However, discrepancies arose when comparing serum cholesterol and LDL readings between the two studies. The referenced study [36] reported significant changes in these metrics one year after surgery, whereas the alterations noted in the current study were more nuanced. Such differences might arise from the lack of comprehensive postoperative patient medication records in our study.

The findings of the current study diverge from those reported in another study [37]. This referenced study was a prospective investigation conducted over three months, involving 36 patients who underwent bariatric surgeries, including sleeve gastrectomy, at Mostafa Khomeini Hospital in Tehran. The primary aim was to discern the effects of BS on cholesterol, TG, LDL, and HDL levels. It was determined that BS led to a significant reduction in TG and an increase in HDL within the first three postoperative months when compared to baseline measurements, underscoring its potential utility in managing hyperlipidemia. However, the changes in LDL and cholesterol were not deemed statistically significant during this timeframe. Contrarily, our study observed a marked decrease in HDL, contrasting the increase noted in the aforementioned study [37] during the same postoperative period. While our study did not find significant changes in TG, the other study [37] reported notable alterations. Additionally, our research identified significant reductions in cholesterol and LDL within the first three postoperative months, a result not echoed in the other study [37]. Potential reasons for these disparities could be the shorter duration of the other study, limited to three months, and its smaller sample size of 36 patients, especially when compared to our more comprehensive sample of 863 participants.

The enhancement in HDL levels is corroborated by another study [38]. This research was a prospective cohort study that juxtaposed the effects of two bariatric surgeries: mini GBS (with 74 patients) and sleeve gastrectomy (with 86 patients) on cholesterol, TG, LDL, and HDL levels. The study scrutinized the variances in these lipid parameters pre- and post-surgery at three distinct intervals (three months, six months, and 12 months) to evaluate the efficacy of both procedures on the lipid profiles of the participants. Collectively, significant alterations were observed in cholesterol, LDL, HDL, and TG levels. However, the efficacy of the two bariatric surgeries was indistinguishable at the 3-month and six-month postoperative marks concerning the aforementioned lipid metrics, attributed to varied selection criteria. Yet, by the 12-month mark, the effectiveness of both surgeries converged, with sleeve gastrectomy exhibiting a slight edge in elevating HDL levels, particularly in patients with a prior history of dyslipidemia [38]. The outcomes observed by [38] a year post-surgery align with the current study's findings, which also reported a statistically significant rise in HDL during the same timeframe.

The findings reported by [32] align with numerous studies that have documented improvements in lipid profiles following LGS surgery. Remarkably, 85% of patients with hyperlipidemia experienced resolution within the first postoperative year. Spanning nine months, this study conducted follow-ups at intervals of three months, six months, and nine months post-surgery. It observed significant enhancements in lipid profile metrics for the majority of participants, including reductions in cholesterol, TG, and LDL levels, and a rise in HDL when compared to pre-surgery values. However, the study had certain limitations, such as its relatively small cohort of 50 LGS patients and the brief duration of follow-up.

Another cohort study by [39] observed a reduction in TG levels one year after SG, with a pre-operative mean of 128.7±66.7 mg/dl, which decreased to 97.1±43.5 mg/dl after one year. Conversely, [40] documented a temporary increase in TG levels one month post-operatively, followed by a non-significant reduction after 12 months.

The present study has several limitations. Firstly, the data recorded in Sage does not specify the diagnosis for each case. As a result, we classified patients with high-risk lipid readings before the operation as hyperlipidemic. Secondly, there was a smaller representation of male patients. Thirdly, certain confounding factors that can influence the serum lipid profile, such as physical activity, dietary habits, and smoking, were not set as exclusion criteria. Lastly, economic factors were not considered.

The current study highlights significant improvements at various time points, though some of these enhancements were not consistently significant. The robustness of these findings can be attributed to the relatively large sample size of 863 participants. This provides clarity and significance, particularly concerning TG and HDL levels, aligning with numerous other studies. Furthermore, consistent observations have been made in the clinic for patients who have undergone regular postoperative follow-ups over many years in the bariatric department. A retrospective study of this nature, with a long-term follow-up extending to five years, offers compelling results that underscore the study's reliability. However, gaps in information and certain excluded criteria, such as medication history and prior diagnoses, might influence the study's outcomes at specific intervals. Overall, the results of this study align with those of patients who underwent LGS at Al-Emadi Hospital. Notably, this hospital has the distinction of being accredited as the first COEMBS in Qatar by The Surgical Review Corporation of the United States of America.

CONCLUSIONS

This analysis delved into the impact of LGS on specific biochemical measurements, with a particular focus on the lipid profile, which includes cholesterol, TG, LDL, and HDL, as markers of hyperlipidemia. Given the constraints of this study, it can be inferred that LGS leads to a notable improvement in serum HDL and TG levels. The findings suggest that obese patients, irrespective of their hyperlipidemia status, experienced enhancements in these metrics during specific post-operative intervals. In essence, it's plausible to anticipate amelioration in comorbidities following significant weight loss due to LGS. However, the absence of improvement during certain post-operative phases underscores the need for additional research to elucidate the underlying reasons. To solidify and expand upon these findings, further long-term investigations are recommended.

Author contributions: AM: conceptualization, data curation, formal analysis, investigation, methodology, resources, validation, visualization, writing-original draft, writing-review, & editing; **ZS:** writing-review, critical editing, formal analysis, software, & validation; **MH:** review & editing; **MM:** writing-review, editing, formal analysis, software, & validation; **MRA & NS:** writing-review & critical editing; & **AA & UA:** review & editing. All authors have agreed with the results and conclusions.

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Ethics declaration: The authors stated that, as per the required of the ethical approval by the Ministry of Public Health in Qatar (MoPH) for this kind of retrospective study, and as per all data extracted by the system, with de-identifying the private data of the patients, consent form is not a required, and informing patients is also not a must. All ethical approvals required from MoPH, Al-Emadi Hospital the setting, where conducted this study, and Management & Science University were added in method.

Declaration of interest: No conflict of interest is declared by the authors.

Data sharing statement: Data supporting the findings and conclusions are available upon request from the corresponding author.

REFERENCES

1. Aldubikhi A. Obesity management in the Saudi population. Saudi Med J. 2023;44(8):725-31. doi:10.15537/smj.2023.44.8.20220724
2. Christ JP, Falcone T. Bariatric surgery improves hyperandrogenism, menstrual irregularities, and metabolic dysfunction among women with polycystic ovary syndrome (PCOS). Obes Surg. 2018;28(8):2171-7. doi:10.1007/s11695-018-3155-6
3. Elkomy N. Risks and rewards of bariatric surgery vs intragastric balloon placement: A comparative study at HMC Qatar. Clin Surg. 2021;4(9):1-5. doi:10.47829/COS.2021.4901
4. Fulton M, Srinivasan VN. Obesity, stigma and discrimination. Treasure Island, FL: StatPearls Publishing; 2023.
5. Cheema S, Abraham A, El-Nahas KG, et al. Assessment of overweight, obesity, central obesity, and type 2 diabetes among adolescents in Qatar: A cross-sectional study. Int J Environ Res Public Health. 2022;19(21):14601. doi:10.3390/ijerph192114601
6. WHO. Obesity and overweight. World Health Organization; 2018. Available at: http://www.who.int/news-room/fact-sheets/detail/obesity-and-overweight (Accessed: 1 June 2023).
7. Mohideen FS, Honest PCR, Syed MA, David KV, Abdulmajeed J, Ramireddy N. Prevalence of multimorbidity among adults attending primary health care centers in Qatar: A retrospective cross-sectional study. J Fam Med Prim Care. 2021;10(5):1823. doi:10.4103/jfmpc.jfmpc_2446_20
8. Taheri S, Al-Thani M. Obesity in Qatar: Current and future strategies. Lancet Diabetes Endocrinol. 2021;9(9):561-2. doi:10.1016/s2213-8587(21)00209-6
9. Aljefree N, Ahmed F. Prevalence of cardiovascular disease and associated risk factors among adult population in the Gulf region: A systematic review. Adv Public Health. 2015;2015. doi:10.1155/2015/235101
10. El-Menyar A, Zubaid M, Rashed W, et al. Comparison of men and women with acute coronary syndrome in six Middle Eastern countries. Am J Cardiol. 2009;104(8):1018-22. doi:10.1016/j.amjcard.2009.06.003
11. El-Menyar A, Zubaid M, Shehab A, et al. Prevalence and impact of cardiovascular risk factors among patients presenting with acute coronary syndrome in the Middle East. Clin Cardiol. 2011;34(1):51-8. doi:10.1002/clc.20873
12. Aljefree N, Ahmed F. Prevalence of cardiovascular disease and associated risk factors among adult population in the Gulf Region: A systematic review. Adv Public Health. 2015;2015:235101. doi:10.1155/2015/235101
13. Tzotzas T, Evangelou P, Kiortsis DN. Obesity, weight loss and conditional cardiovascular risk factors. Obes Rev. 2011;12(5):e282-289. doi:10.1111/j.1467-789X.2010.00807.x
14. Atalay G, Parlak E. Laparoscopic sleeve gastrectomy: Do lipid profile and cardiovascular risk predictor improve in moderately, morbidly, and super obese patients? Bariatric Surg Pract Patient Care. 2021;16(3):161-8. doi:10.1089/bari.2020.0099
15. Müller TD, Blüher M. Obesity treatment: Will pharmacotherapies replace metabolic surgery in the future? Front Endocrinol (Lausanne). 2022;13:1016613. doi:10.3389/fendo.2022.1016613
16. Wang L, Lin M, Yu J, et al. The impact of bariatric surgery versus non-surgical treatment on blood pressure: Systematic review and meta-analysis. Obes Surg. 2021;31(11):4970-84. doi:10.1007/s11695-021-05671-9
17. Liao J, Yin Y, Zhong J, et al. Bariatric surgery and health outcomes: An umbrella analysis. Front Endocrinol (Lausanne). 2022;13:1016613. doi:10.3389/fendo.2022.1016613
18. Tham KW, Abdul Ghani R, Cua SC, et al. Obesity in South and Southeast Asia–A new consensus on care and management. Obes Rev. 2023;24(2):e13520. doi:10.1111/obr.13520
19. Perone F, Pingitore A, Conte E, et al. Obesity and cardiovascular risk: Systematic intervention is the key for prevention. Healthcare (Basel). 2023;11(6):902. doi:10.3390/healthcare11060902
20. Baharuddin DM, Payus AO, Abdel Malek Fahmy EH, et al. Bariatric surgery and its impact on fertility, pregnancy and its outcome: A narrative review. Ann Med Surg (Lond). 2021;72:103038. doi:10.1016/j.amsu.2021.103038
21. Holanda N, Crispim N, Carlos I, Moura T, Nóbrega E, Bandeira F. Musculoskeletal effects of obesity and bariatric surgery–A narrative review. Arch Endocrinol Metab. 2022;66(5):621-32. doi:10.20945/2359-3997000000551

22. Pedroso FE, Gander J, Oh PS, Zitsman JL. Laparoscopic vertical sleeve gastrectomy significantly improves short term weight loss as compared to laparoscopic adjustable gastric band placement in morbidly obese adolescent patients. J Pediatr Surg. 2015;50(1):115-22. doi:10.1016/j.jpedsurg.2014.10.014
23. Akpinar EO, Marang-van de Mheen PJ, Nienhuijs SW, Greve JWM, Liem RSL. National bariatric surgery registries: An international comparison. Obes Surg. 2021;31(7):3031-9. doi:10.1007/s11695-021-05359-0
24. Kizy S, Jahansouz C, Downey MC, Hevelone N, Ikramuddin S, Leslie D. National trends in bariatric surgery 2012-2015: Demographics, procedure selection, readmissions, and cost. Obes Surg. 2017;27(11):2933-9. doi:10.1007/s11695-017-2719-1
25. Cosentino C, Marchetti C, Monami M, Mannucci E, Cresci B. Efficacy and effects of bariatric surgery in the treatment of obesity: Network meta-analysis of randomized controlled trials. Nutr Metab Cardiovasc Dis. 2021;31(10):2815-24. doi:10.1016/j.numecd.2021.06.018
26. Level L, Rodríguez G, Piñango S, Avariano Y. Laparoscopic Roux-en-Y gastric bypass versus laparoscopic sleeve gastrectomy: A 5-year follow-up prospective study of 200 cases. SN Compr Clin Med. 2021;3(10):2180-7. doi:10.1007/s42399-021-00973-6
27. Van Osdol AD, Grover BT, Borgert AJ, Kallies KJ, Kothari SN. Impact of laparoscopic Roux-en-Y gastric bypass versus sleeve gastrectomy on postoperative lipid values. Surg Obes Relat Dis. 2017;13(3):399-403. doi:10.1016/j.soard.2016.09.031
28. Tabesh MR, Abolhasani M, Zali MR, et al. The impact of bariatric surgery procedures on the modulation of cardiometabolic risk factors in patients with severe obesity: A 12-month follow-up. J Int Med Res. 2022;50(10):3000605221119657. doi:10.1177/03000605221119657
29. Ruiz-Tovar J, Zubiaga L, Llavero C, Diez M, Arroyo A, Calpena R. Serum cholesterol by morbidly obese patients after laparoscopic sleeve gastrectomy and additional physical activity. Obes Surg. 2014;24(3):385-9. doi:10.1007/s11695-013-1082-0
30. Elsawaf M, Ashour M, Metwaly M, Hashish M. One-year outcome of laparoscopic sleeve gastrectomy in morbidly obese adolescents. Ann Pediatr Surg. 2021;17(1):1-7. doi:10.1186/s43159-021-00098-4
31. Ferri FA, Frieder JS, Blanco DG, et al. Short-term multiorgan metabolic benefits of rapid weight loss after sleeve gastrectomy in severely obese patients. Surg Obes Relat Dis. 2021;17(2):284-91. doi:10.1016/j.soard.2020.10.003
32. Singhal S, Agarwal D, Kanojiya R, Arora D, Avesthi A, Kothari A. Effect of laparoscopic sleeve gastrectomy on lipid profile of obese patients in complete nine month follow up. Int Surg J. 2016;3(1):42-6. doi:10.18203/2349-2902.isj20151486
33. Talebpour M, Talebpour A, Barzin G, Shariat Moharari R, Khajavi MR. Effects of laparoscopic gastric plication (LGP) in patients with type 2 diabetes, one year follow-up. J Diabetes Metab Disord. 2015;14:1-4. doi:10.1186/s40200-015-0188-4
34. Gülşen Atalay B, Parlak E. Laparoscopic sleeve gastrectomy: Do lipid profile and cardiovascular risk predictor improve in moderately, morbidly, and super obese patients? Bariatric Surg Pract Patient Care. 2021;16(3):161-8. doi:10.1089/bari.2020.0099
35. Zaki MKS, Al-Jefri OH, Kordi RE, et al. Correlation of bariatric surgery effect on lipid profile among obese patients. Cureus. 2021;13(9):e18118. doi:10.7759/cureus.18118
36. Heffron SP, Parikh A, Volodarskiy A, et al. Changes in lipid profile of obese patients following contemporary bariatric surgery: A meta-analysis. Am J Med. 2016;129(9):952-9. doi:10.1016/j.amjmed.2016.02.004
37. Khalaj A, Tasdighi E, Hosseinpanah F, et al. Two-year outcomes of sleeve gastrectomy versus gastric bypass: First report based on Tehran obesity treatment study (TOTS). BMC Surg. 2020;20(1):1-14. doi:10.1186/s12893-020-00819-3
38. Milone M, Lupoli R, Maietta P, et al. Lipid profile changes in patients undergoing bariatric surgery: A comparative study between sleeve gastrectomy and mini-gastric bypass. Int J Surg. 2015;14:28-32. doi:10.1016/j.ijsu.2014.12.025
39. Strain GW, Saif T, Ebel F, et al. Lipid profile changes in the severely obese after laparoscopic sleeve gastrectomy (LSG), 1, 3, and 5 years after surgery. Obes Surg. 2015;25(2):285-9. doi:10.1007/s11695-014-1351-6
40. Szczuko M, Komorniak N, Hoffmann M, et al. Body weight reduction and biochemical parameters of the patients after RYGB and SG bariatric procedures in 12-month observation. Obes Surg. 2017;27(4):940-7. doi:10.1007/s11695-016-2400-0

