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CLINICAL RESEARCH

Effects of Laparoscopic Roux-en-Y Gastric Bypass (LRYGB) on Weight Loss and Biomarker Parameters in Morbidly Obese Patients: A 12-Month Follow-Up

Karamollah Toolabi · Saeed Arefanian · Mahdieh Golzarand · Hossein Arefanian

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Abstract

Background Laparoscopic Roux-en-Y gastric bypass (LRYGB) is suggested as the gold standard of the surgical techniques for morbid obesity treatment. The aim of this study was to evaluate the weight loss and biomarker parameter changes over a 1-year period following LRYGB in Iranian morbidly obese patients.

Methods Sixty patients who had undergone LRYGB from June 2006 to August 2008 were followed up. Complication rates and changes in anthropometric indices, metabolic parameters, and obesity-related comorbidities were evaluated.

Results During the mean follow-up duration of 27.2± 9.4 months, the mean weight reduced from 128.8±20.4 to 86.9±12.7 kg with excess weight loss (%EWL) of 63.8± 15.6%. The male young-adolescent patients showed more weight loss than females. Biochemical parameter changes were reduction of fasting blood sugar by 19%, total cholesterol by 17%, triglyceride by 30%, low-density lipoprotein by 19%, aspartate aminotransferase by 44%, alanine aminotransferase by 52%, alkaline phosphatase by 33%, and uric acid by 19%, while high-density lipoprotein (HDL) levels increased by 22%. HDL level change was the only biomarker factor showing correlation with age (P=0.005, r=−0.353, R^2=0.125). Obesity comorbidities were resolved considerably. There were two cases of surgical complications and no case of mortality.

Conclusion LRYGB appears to be a safe and effective procedure with a low complication rate in Iranian morbidly obese patients. It results in weight loss, reduction in obesity comorbidities, increasing HDL, and decreasing other measured plasma biochemical parameters. Based on our results, we suggest that LRYGB would benefit young male morbidly obese patients more than others.

Keywords Morbid obesity · Gastric bypass · Hyperlipidemias · Comorbidity · Weight loss · Hyperglycemia · Liver function tests · Uric acid

K. Toolabi
Department of Surgery, Imam Khomeini Hospital,
Tehran University of Medical Sciences,
Tehran, Iran

S. Arefanian
School of Medicine, Tehran University of Medical Sciences,
Tehran, Iran

M. Golzarand
Obesity Research Center, Research Institute for Endocrine Sciences, Shahid Beheshti University of Medical Sciences,
Tehran, Iran

H. Arefanian
Endocrinology and Metabolism Research Center, Dr. Shariati Hospital, Tehran University of Medical Sciences,
Tehran, Iran

S. Arefanian (✉)
No. 26, Chamran Building, Parvaneh Alley, Shahid Gomnam Expressway, Kargar-e-Shomali Street,
Tehran, Iran
e-mail: s.arefanian83@gmail.com

Introduction

Obesity is the most common disease of the twenty-first century which is associated with increased risk of chronic diseases including cardiovascular disease, diabetes mellitus (DM), and certain organ cancers such as colon, breast, and pancreas [1–4]. The Iranian society is burdened with obesity and its increasing prevalence as well as other countries worldwide [5–7]. At the time of writing the present paper, the latest prevalence rate reports had revealed that 19.7% of Iranian adults (20–70 years) were obese and 38% suffered from being overweight [8].

In parallel with an increasing trend in obesity and the modest weight loss of nonsurgical procedures including diet, lifestyle modification, and behavioral and pharmaceutical therapy in morbidly obese patients, bariatric surgery has been developed [9]. Several studies have demonstrated that bariatric surgery, as a popular approach, is the most effective procedure leading to significant and durable weight loss and improvement of obesity-related diseases [11–16].

After the development of minimally invasive surgical approaches, the laparoscopic bariatric surgery became very popular. Laparoscopic Roux-en-Y gastric bypass (LRYGB) is one of the most popular techniques, which is known as the gold standard due to its safety and easy reproducibility [10, 17, 18]. A meta-analysis has shown that patients who had undergone RYGB lost 61.5%, 69.7%, and 71.2% of their excess weight during 1-, 2-, and 3-year postoperation periods, respectively [19]. In addition to weight loss, LRYGB results in decreasing mortality rates of comorbidities such as coronary heart disease and diabetes by more than 50% and 90%, respectively [19–21].

In our literature search, no study methodically analyzing the LRYGB outcomes in Iran was found, although it has been performed in Iran since 2005. This study aimed to evaluate weight loss and biochemical parameter changes in a 1-year postoperative follow-up in patients who had undergone LRYGB in a surgery clinic in Iran.

Materials and Methods

Subjects

Sixty obese patients who had undergone LRYGB surgery between June 2006 and August 2008 were included in this study. Surgical criteria were defined according to the National Health Institute's guidelines as body mass index (BMI)>40 kg/m^2 or BMI>35 kg/m^2 with a comorbidity and failure to lose weight by nonsurgical treatments [22]. Subjects who suffer from major depression, psychosis, alcoholism, or opioid addiction were excluded from the study. All patients were visited preoperatively, the surgical procedure was explained to them, and they were advised on its benefits and complications. The operations were performed by a single surgeon (K.T.) at the Erfan and Milad hospitals in Tehran, Iran. The follow-up visits were at 1, 3, 6, and 12 months postoperation times. The study protocol was approved by the ethics committee of Tehran University of Medical Sciences, and informed consent was obtained from all participants.

Patients' weight and height were measured using scales (Seca, Germany) and a tape measure, respectively. BMI was calculated as the weight in kilograms divided by the square of the height in meters. The ideal body weight was figured using the suggested formula by Deitel et al. [23]. Excess weight was calculated as preoperative weight minus ideal weight, excess weight loss was calculated as [(preoperation weight−postoperation weight)/(preoperation weight−ideal weight)]×100, and percent excess BMI loss (%EBL) was figured subsequently as [(preoperative BMI−postoperative BMI)/(postoperative BMI−25)]×100 [23]. Fasting blood samples for measurement of fasting blood sugar (FBS), lipid profile, uric acid, and hepatic enzymes were obtained preoperatively and 1-year postoperatively. FBS, total cholesterol (TC), high-density lipoprotein (HDL), triglyceride (TG), uric acid, alanine aminotransferase (ALT), aspartate aminotransferase (AST), and alkaline phosphatase (ALK P) levels were determined using enzymatic–colorimetric assay by commercial kits. Low-density lipoprotein (LDL) concentration was calculated by the Friedewald equation as LDL=TC−HDL−TG/5 [24].

Surgical Technique

The laparoscopic five-port technique was used to perform the LRYGB surgery. The first 10-mm trocar was inserted about 20 cm below the xiphoid process for the 30° telescope. Two 12-mm trocars were placed in the right and left hypogastric regions, one 5-mm trocar in the subxiphoid region for liver retraction and another one in the left subcostal for the assistant's use. Initially, the greater omentum was dissected up to the transverse colon with the patient in the supine position. Subsequently, the small intestine was transected about 35 cm down the Trietz ligament to create the biliopancreatic limb. The jejunojejunostomy was made by anastomosis of the proximal transected head to the small intestine, using the side-to-side technique. The length of the Roux limb was 100–150 cm according to the patient's obesity severity. In the next step, the lesser sac was dissected from the origin of the third artery in the lesser curvature and the stomach was transected 4–6 cm down the gastroesophageal junction with 3.5 mm staplers, then the transection was continued vertically to the angle of His. The gastrojejunostomy was made by end-to-side anastomosis and antecolic approach. The mesenteric defects were closed to avoid internal hernia. Control radiologic study was performed 24 h after the surgery and an oral diet was started in case of a normal result.

Statistical Analysis

The data were presented as mean with standard deviation (SD) and median with interquartile range (IQR) for variables with and without a normal distribution, respectively. The differences between preoperation and postoperation means were analyzed using paired-samples Student's *t* test. Parametric Student's *t* and one-way ANOVA tests were used for comparing between groups meeting the respective tests assumptions. Nonparametric Student's *t* and Kruskal–Wallis tests were applied for comparison between groups that did not met the tests assumptions. The level of significance was defined at $P<0.05$. The significance level considered for Kruskal–Wallis post hoc analysis was $P<0.0125$ according to Bonferroni correction. Statistical analysis was performed using SPSS software, version 15 (SPSS Inc., Chicago, IL, USA).

Results

Sixty patients who had undergone LRYGB surgery for morbid obesity between June 2006 and August 2008 were included in this study; the data for preoperative, 1-month, 3-month, 6-month, and 1-year postoperative periods were analyzed. The cases comprise 47 females and 13 males with mean age of 36.1±11.7 and 29.3±9.7 years, respectively. The mean patients' preoperative weight was 128.8±20.4 kg and the mean BMI was 46.2±5.9 kg/m^2 (46.8±5.6 kg/m^2 for males and 46±6.1 kg/m^2 for females). Hypertriglyceridemia and hypercholesterolemia were the two most prevalent comorbidities in present study. The complete demographic data and patients' preoperative comorbidities are presented in Table 1.

The operation time ranged from 75 to 375 min with an average of 176±57 min. There was neither need for blood transfusion nor conversion to open surgery during the LRYGB operations. Mean hospital stay was 3.8±1.2 days (2–9 days). The short-term complications consisted of one case of intestinal obstruction and one case of intestinal bleeding and melena. There were no cases of wound infection, anastomosis leakage, marginal ulcer, anastomosis constriction, incisional hernia, or pulmonary emboli.

In our follow-up, the patients' rate of 1-month visit response was 73% (n=44; 38 females and 6 males). The 3- and 6-month follow-up response rates were 68% (n=41; 34 females and 7 males) and 83% (n=50; 40 females and 10 males), respectively. In the 1-year follow-up, the mean weight loss for 1, 3, 6, and 12 months after surgery were 10.5±5.9, 21.6±7.7, 31.0±11.1, and 41.9±14.1 kg, respectively. The mean BMI changed to 31.2±4.5 kg/m^2 with the %EBL of 72.2%±18.8% after 1 year (Table 2). Biochemical parameter changes were reduction of FBS by 19%, TC by 17%, TG by 30%, LDL by 19%, AST by 44%, ALT by 52%, ALK P by 33%, and uric acid by 19%, while HDL levels increased by 22% (Table 2). Sleep apnea and DM were the most resolved comorbidities in our follow-up with resolution rates of 100% and 93%, respectively. Stress urinary incontinence (SUI; 92%), hypercholesterolemia (84%), and hypertriglyceridemia (83%) resolved by the rates mentioned in parentheses (Fig. 1).

According to our patients' age median of 33.5, patients' data were divided into two age groups of young-adolescent (34 >age) and middle-aged mature (age ≥34). Data analysis between two age groups demonstrated a statistically significant difference in 1-, 3-, and 6-month weight loss and HDL changes (Table 3). There were six adolescent patients (age ≤20) in our study who showed higher 1-month weight loss (P=0.02) and lower LDL change (P=0.03) than

Table 1 Participants demographic characteristics [mean±SD] and preoperative comorbidity [number (percent)]

	Female	Male	Total
Demographic data			
Age (years)	36.1±11.7	29.3±9.7	34.7±11.6
Weight (kg)	122.9±15.7	149.9±22	128.8±20.4
Height(cm)	163.6±6.3	178.7±7.1	166.9±9.0
BMI (kg/m^2)	46±6.1	46.8±5.6	46.2±5.9
Comorbidities			
Diabetes	10 (21.2)	5 (34.8)	15 (25)
Hypercholesterolemia	25 (53.1)	6 (46.1)	31 (51.6)
Hypertriglyceridemia	31 (65.9)	10 (76.9)	41 (68.3)
Hypertension	5 (10.6)	2 (15.3)	7 (11.6)
GERD/heartburn	21 (44.6)	6 (46.1)	27 (45.0)
Sleep apnea	16 (34.0)	5 (38.4)	21 (35.0)
SUI	10 (21.2)	2 (15.3)	12 (20.0)
Total (%)	47 (78.3)	13 (21.7)	60 (100)

Table 2 Preoperation and postoperation comparison of weight loss and biomarker changes

	Preoperation	Postoperation	P value
Weight (kg)	128.8±20.4	86.9±12.7	<0.001
BMI (kg/m^2)	46.2±5.9	31.2±4.5	<0.001
%EBL, 1 month (n=44)	–	19.3±10.0	–
%EBL, 3 months (n=41)	–	38.0±12.8	–
%EBL, 6 months (n=50)	–	54.9±16.1	–
%EBL, 12 months (n=60)	–	72.2±18.8	–
FBS (mg/dL)	115.3±43.8	86.0±10.0	<0.001
HDL (mg/dL)	40.3±6.6	48.7±8.4	<0.001
LDL (mg/dL)	123±24.6	98.2±20.8	<0.001
TG (mg/dL)	180.7±74.3	118.1±42.6	<0.001
Cholesterol (mg/dL)	203.5±31.1	168.5±30	<0.001
AST (IU/L)	47.6±34	22.2±11.2	<0.001
ALT (IU/L)	53.8±36.4	20.3±7	<0.001
ALK P (IU/L)	271.9±83.8	175.5±76	<0.001
Uric acid (mg/dL)	6.28±1.12	5.0±0.78	<0.001

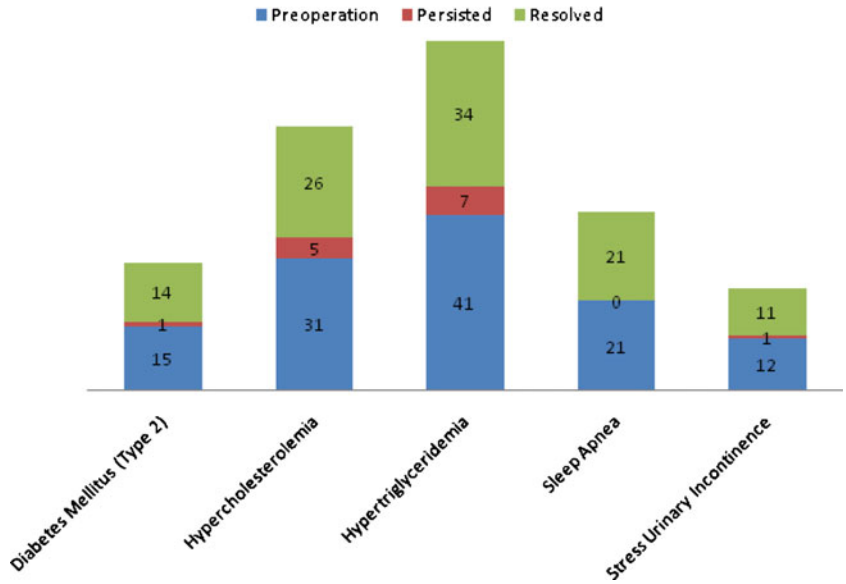

Fig. 1 Preoperative and 1 year postoperative frequency of comorbidities

the rest of the cases, while their lower FBS changes were reaching statistical significance (P=0.051). Considering the lowest menopause age in our cases, 44 years old, as a cut-point, patients with the age of ≥44 (n=13) demonstrated significant lower weight loss in all of the four time intervals than the younger cases and their higher changes in FBS were almost significant (P=0.050).

In our data analysis, males (n=13) had lost more weight in the 3-month (P=0.03), 6-month (P=0.02), and 12-month (P=0.001) periods than the females (n=47). The same difference between the 1-month results failed to be statistically significant (P=0.07). Our analysis revealed no other differences between the two sex groups (Table 4). Nonparametric Student's t test did not show any statistically significant difference in studied factors between menopause (n=6) and nonmenopause (n=5) mature (age ≥44) female patients. The higher FBS changes in the nonmenopause group were reaching statistical significance (P=0.052; Table 5).

Data analysis after grouping the cases according to both factors of sex and age (young-adolescent and middle-aged mature) revealed a significant difference for 12-month weight loss, FBS, and HDL changes (Table 6). The male young-adolescent group had higher weight loss than both age groups of the female gender (P<0.001 for both). The

Table 3 Comparison of surgery duration, hospital stay, and postoperative weight loss and biomarker changes based on patients age groups

	Young-adolescent (34>) [n=30]	Middle-aged mature (≥34)[n=30]	P value
Surgery duration (min)	175.6±53.3	176.3±61.4	0.96
Hospital stay (day)	3.8±1.2	3.8±1.2	0.84
1-month weight loss (kg)	13.2±6.3 [n=24]	7.3±3.1 [n=20]	<0.001
3-month weight loss (kg)	24.0±6.8 [n=20]	19.2±8.0 [n=21]	0.01
6-month weight loss (kg)	34.2±10.1 [n=24]	28.0±11.2 [n=26]	0.04
12-month weight loss (kg)	44.7±14.4	39.1±13.4	0.12
FBS (mg/dL)	20.9±35.2	37.7±42.6	0.10
HDL (mg/dL)	12.1±6.9	4.6±5.8	<0.001
LDL (mg/dL)	24.6±16.9	24.8±12.4	0.95
TG (mg/dL)	64.9±69.8	60.3±44.8	0.76
Cholesterol (mg/dL)	34.4±20.5	35.6±21.2	0.82
AST (IU/L)	28.2±41.9	22.5±14.3	0.48
ALT (IU/L)	35.7±45.0	31.4±17.9	0.63
ALK P (IU/L)	80.4±72.5	112.4±67.1	0.08
Uric acid (mg/dL)	1.4±1.1	1.1±0.6	0.26

Table 4 Comparison of surgery duration, hospital stay, and postoperative weight loss and biomarker changes based on patients' sex

	Female (n=47)	Male (n=13)	P value
Surgery duration (min)	176.1±55.1	175.3±65.8	0.76
Hospital stay	3.2±1.1	4.2±1.6	0.31
1-month weight loss (kg)	9.7±5.1	15.5±8.6	0.07
3-month weight loss (kg)	20.3±6.8	27.7±9.7	0.03
6-month weight loss (kg)	28.8±9.6	39.7±12.6	0.006
12-month weight loss (kg)	38.3±11.6	54.8±15.1	0.001
FBS (mg/dL)	25.6±32.0	42.7±52.5	0.72
HDL (mg/dL)	8.3±7.3	8.6±7.7	0.49
LDL (mg/dL)	23.4±15.5	29.4±10.8	0.15
TG (mg/dL)	54.4±42.5	92.1±92.3	0.34
Cholesterol (mg/dL)	33.1±21.0	41.6±19.0	0.34
AST (IU/L)	22.8±19.9	34.4±56.0	0.81
ALT (IU/L)	31.1±25.4	42.1±56.0	0.75
ALK P (IU/L)	99.4±65.9	85.4±89.7	0.97
Uric acid (mg/dL)	1.1±0.7	1.8±1.3	0.10

Table 5 Comparison of surgery duration, hospital stay, and postoperative weight loss and biomarker changes based on being menopause or nonmenopause in females aged ≥44 years old

	Menopause [*n*=6]	Nonmenopause [*n*=5]	*P* value
Surgery duration (min)	180.0±58.3	171.0±12.4	0.66
Hospital stay	3.5±0.5	3.4±0.5	0.79
1-month weight loss (kg)	7.1±2.3 [*n*=6]	6.7±2.2 [*n*=4]	0.61
3-month weight loss (kg)	15.7±1.2 [*n*=4]	18.2±4.9 [*n*=4]	0.34
6-month weight loss (kg)	23.8±7.2 [*n*=5]	19.7±7.2 [*n*=4]	0.55
12-month weight loss (kg)	34.6±11.9	31.8±6.3	0.53
FBS (mg/dL)	19.5±22.3	70.6±51.5	0.052
HDL (mg/dL)	7.6±2.8	5.8±4.8	0.53
LDL (mg/dL)	23.0±12.1	20.4±7.9	0.79
TG (mg/dL)	64.6±51.1	38.0±24.4	0.24
Cholesterol (mg/dL)	21.0±28.6	33.8±7.9	0.32
AST (IU/L)	28.5±7.8	32.6±25.4	0.42
ALT (IU/L)	40.8±15.2	42.0±28.0	0.42
ALK P (IU/L)	110.5±32.0	148.2±51.9	0.53
Uric acid (mg/dL)	0.97±0.53	1.2±0.66	0.93

male middle-aged mature group demonstrated more decrease in FBS level than female young-adolescent group (P=0.008). The female middle-aged mature group had less increase in their HDL level than the young-adolescent groups of both sexes (P=0.009 for male and P=0.001 for female). Regression analysis demonstrated a reverse correlation between HDL changes and age (P=0.005, r=−0.353, R^2=0.125; Fig. 2a) with a more prominent correlation in the male patients (P=0.036, r=−0.584, R^2=0.341; Fig. 2a, b).

Discussion

The purpose of this study was to evaluate the effects of LRYGB on the weight loss and serum biomarker changes in the 1-year follow-up of the morbidly obese patients in our clinic. Average operation time in this study was 176±57 min. Nguyen et al. and Schauer et al. reported 225 and 260 min as their average operation time, respectively [25, 26]. These data show that our operation time can be considered acceptable compared to other published studies. Our mean operation time for the last 30 cases was 147±36 min, which was shorter than the mean of 204±59 min for the first 30 ones (P<0.001). This could indicate the surgeon's improvement in the learning curve.

Weight Loss

In our 1 year follow-up, the patients had a mean weight loss of 41.9 kg and %EBL of 72.2%. De Mario et al. reported a %EWL of 70%, while this rate was 69% in

Table 6 Comparison of surgery duration, hospital stay, postoperative weight loss and biomarker changes between patients based on sex–age groups

	Female young-adolescent [*n*=21]	Female middle-aged mature [*n*=26]	Male young-adolescent [*n*=9]	Male middle-aged mature [*n*=4]	*P* value
Surgery duration (min): median (IQR)[a]	165.0 (85)	172.5 (83)	200.0 (60)	127.5 (75)	0.12
Hospital stay: median (IQR)[a]	3.0 (2)	4.0 (1)	4.0 (1)	5.0 (5)	0.48
12-month weight loss (kg): mean±SD[b]	38.4±9.6[c]	38.1±13.2[c]	59.2±13.5[c]	45.0±15.6	<0.001
FBS (mg/dL): median (IQR)[a]	10.0 (31.0)[c]	21.0 (26.2)	10.0 (30.0)	66.5 (128.7)[c]	0.02
HDL (mg/dL): mean±SD[b]	12.4±7.6[c]	5.0±5.3[c]	11.3±5.4[c]	2.5±9.3	0.001
LDL (mg/dL): median (IQR)[a]	23.0 (25.0)	23.0 (17.5)	23.0 (13.5)	36.5 (24.5)	0.23
TG (mg/dL): median (IQR)[a]	58.0 (38.5)	58.0 (64.7)	58.0 (130.5)	62.5 (37.0)	0.76
Cholesterol (mg/dL): median (IQR)[a]	34.0 (26.5)	30.5 (16.0)	31.0 (22.5)	45.5 (26.2)	0.34
AST (IU/L): median (IQR)[a]	25.0 (19.5)	25.0 (9.5)	25.0 (31.0)	23.0 (9.2)	0.95
ALT (IU/L): median (IQR)[a]	25.0 (28.5)	35.0 (15.5)	36.0 (41.0)	27.5 (25.5)	0.81
ALK P (IU/L): median (IQR)[a]	105.0 (123.0)	123.5 (43.0)	99.0 (133.5)	128.0 (199.7)	0.58
Uric acid (mg/dL): median (IQR)[a]	1.1 (0.7)	1.1 (0.6)	1.6 (2.3)	1.4 (1.3)	0.34

[a] Factors analyzed by nonparametric ANOVA (Kruskal–Wallis) test

[b] Factors analyzed by parametric ANOVA test

[c] Groups showing statistically significant difference in post hoc analysis

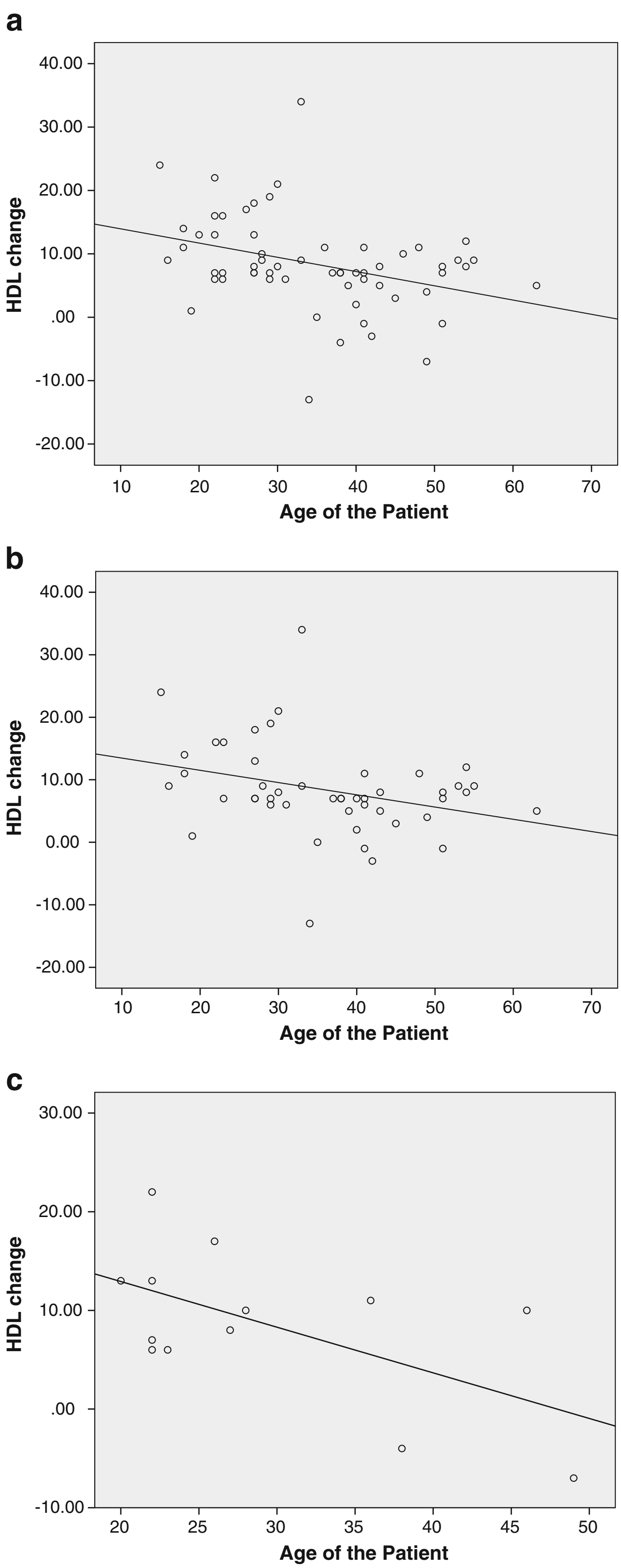

Fig. 2 **a** HDL changes and age relation in all patients (p=0.005, r=−0.353, R^2=0.125), **b** HDL changes and age relation in female patients (p=0.033, r=−0.311, R^2=0.097), and **c** HDL changes and age relation in male patients (p=0.036, r=−0.584, R^2=0.341)

studies performed by Higa et al. and Han et al. [27–29]. Comparing two groups of LRYGB and laparoscopic sleeve gastrectomy, Lakdawala et al. reported %EWL of 62.2% and 76.1% for the respective groups [30]. Hauser et al., in a study on American obese veterans, reported a rate of 56% EWL among their study group [31]. As demonstrated in Tables 3 and 4, our results showed higher weight loss for the young-adolescent age group (1-, 3-, and 6-month periods) and male group (3-, 6-, and 12-month periods) than the middle-aged mature and female groups, respectively. There was no significant difference in preoperative weight between the two age groups, while this difference was significant for two sex groups (P<0.001). Meanwhile, the higher %EBL in the male group continues to be significant for the 1-year postoperative period (79% compared to 70%, P=0.03). *These results suggest that being male and young may potentiate the morbidly obese patient for more weight loss.* The data analysis confirmed this by revealing significantly more weight loss in male young-adolescent group than both female young-adolescent and middle-aged groups (Table 6).

In a follow-up of four adolescent morbidly obese patients, Stanford et al. reported a %EWL of 87% [32]. There were six patients aged ≤20 in our cases whose average %EBL and weight loss were 82.9±22.8% and 47.5±18.7 kg, respectively. Our initial analysis showed significantly higher weight loss and %EBL in the 1-month period for patients aged ≤20 as 13.8 kg and 83.9%, respectively. On the other hand, patients aged ≥44 demonstrated lower weight loss for all time periods in the initial analysis. Further analysis revealed that patients who are ≥44 years old had significantly lower preoperative weight than others and there was no significant difference between %EBL of this group and the rest of the cases. *These results suggest that being young can be a positive factor for weight loss after LRYGB while being older is not a negative one.*

Analysis of the diabetic patients' results showed a 1-year %EBL of 68.6% for diabetic patients compared to 73.3% for nondiabetic patients of which the difference could not reach significance (P=0.51), while a significant difference was reported by other studies [33, 34]. The %EBL rates in diabetic patients for the 1-month (n=11) and 6-month (n=14) months were lower in our study than nondiabetics with P values of 0.02 and 0.04, respectively. This difference could be due to unknown changes in diabetic patients' metabolism or the antidiabetic drugs' weight gain side effect [33].

Complications

For short-term complications, there was one case of intestinal obstruction (1.66%) due to internal hernia and one case of melena and intestinal bleeding (1.66%) in this study. Internal hernia can occur in three sites after LRYGB surgery: defect in the small intestine anastomosis site, defect in the transverse mesocolon with intestinal hernia into the lesser sac, and Peterson defect in the posterior Roux limb [27]. The obstruction complication in this study was due to internal hernia in the jejunojejunostomy site between the stay stitch and anastomosis site.

Anastomosis leakage is a very dangerous complication in the RYGB technique. The technique used for gastrojejunostomy anastomosis in the present study was linear and in one layer, while another suggested technique is anastomosis in two layers to avoid leakage [27]. It is suggested that performing routine upper gastrointestinal (GI) series study is unnecessary because of low rate of leakage [29, 35]. As this was the first national experience of an LRYGB case series in our country, a control radiology study was performed for the patients and oral diet was started in case of being normal.

Bleeding is another complication, with making the gastric pouch by perigastric technique suggested as a cause [29]. We used the perigastric technique in order to avoid vagus nerve injury and dumping syndrome. The intraoperative bleeding and need for blood transfusion in our study was zero. Having the same rate of intraoperative bleeding, Nguyen et al. proposed that the *postoperative* bleeding rate is higher in LRYGB than in the open technique [25]. In our cases, one patient was admitted to the emergency ward for melena and severe GI bleeding (Hgb=8 mg/dL) 13 days after the operation. The patient was transferred to the operating room and laparotomy was performed. Finding no specific source for the bleeding, the patient was transferred to the ward. After receiving 4 units of packed cells and supportive care, the patient was discharged with no other sign of GI bleeding.

Postoperative deep venous thrombosis (DVT) is a serious concern in open RYGB. Little information about its risk in the laparoscopic technique is available. Increased abdominal pressure after gas insufflation theoretically can decrease venous return. In a comparison of femoral vein flow between two groups of open RYGB and LRYGB, Nguyen et al. reported a significant increase in venous stasis in the laparoscopic group [36]. Putting the patient in the Trendelenburg position is another factor which encourages the decrease in venous return. In this study, we had no cases of pulmonary emboli or DVT. Prophylactic enoxaparin was administered to our patients.

Fasting Blood Sugar Changes

LRYGB shows a good effect in controlling the blood sugar level in morbidly obese patients [33]. The mean FBS level of 115.3±43.8 mg/dL (6.3±2.4 mmol/L) before operation was decreased to 86.0±10.0 mg/dL (4.7±0.5 mmol/L) in our 1 year follow-up. Four of the patients with preoperative FBS≥126 mg/dL and one of the patients with preoperative FBS<126 mg/dL were known cases of DM and were receiving antidiabetic drugs. They were advised to consult their endocrinologist to stop or adjust the dose of their drugs after surgery. In our follow-up, only one patient was still receiving insulin at a lower dosage 1 year after surgery. None of the patients had FBS≥126 mg/dL in the 12-month visits. In a study on 191 morbidly obese patients with DM or impaired fasting glucose, a significant decrease in fasting plasma glucose from 187 to 100 mg/dL was observed in a 5-year postoperation period after LRYGB. The surgery showed a significant decrease in receiving antidiabetic oral agents and insulin by 52% and 21%, respectively [33].

The effect of LRYGB on blood sugar level may be explained as a consequence of the patient's weight loss, decreased body calorie intake, and changes in hormone metabolism. *Besides weight loss as an important factor, other factors should be involved as it seems that blood sugar begins to decrease before weight loss reaches a significant point*. Reduction in calorie intake may play a role in this step; however, the exact mechanism of glycemic control achieved by bariatric surgery is not known.

Study of FBS changes in different age groups demonstrated almost significant lower FBS change in adolescent patients (age ≤20) and higher changes in patients ≥44 compared to the rest of the cases. Combining these results with lower preoperative FBS in the adolescent group (P=0.04) and almost higher preoperative FBS in patients ≥44 (P=0.06) implies that LRYGB has a curative effect for adults with high blood sugar while keeping the young patients with more normal blood sugar levels from becoming diabetic in the future. The nonmenopause patients in this study demonstrated a higher decrease rate in FBS level than the menopause group which our results failed to prove statistically (P=0.052).

Lipid Profile Changes

It is suggested that bypass is effective in improving morbid obesity comorbidities including hyperlipidemia [37]. The results of the present study show a decrease in TC by 17%, TG by 30%, and LDL by 19% and increase in HDL by 22%. These changes in a similar study performed by Nguyen et al. on 95 morbidly obese patients were 12%, 63%, 31%, and 39%, respectively [38]. As obesity and hyperlipidemia are independent risk factors for coronary diseases [38], these results showed that LRYGB can be effective in treatment or prevention of ischemic heart diseases in morbidly obese patients. The young-adolescent age group in our study showed higher increase in HDL level. A similar result was revealed as lower HDL changes in the female middle-aged mature group than the young-adolescent group of both sex groups. Regression analysis demonstrated a reverse correlation between HDL changes and age (P=0.005, r=−0.353, R^2=0.125), illustrating that *younger patients have greater changes in their HDL*, probably because of their healthier liver and more active lifestyle (Fig. 2).

Other Biomarkers and Comorbidities

Our results showed encouraging results in decreasing ALT, AST, ALK P, and uric acid levels in morbidly obese patients 12 months after the LRYGB. ALT and AST levels can be used as an estimate for liver fat storage and function. Johansson et al. reported a decrease in the ALT level of 21 patients 12 months after the RYGB [39]. In 2007, Jouët et al. suggested sleep obstructive apnea as an independent risk factor for increasing liver enzymes [40]. Our results show a 52% decrease in ALT level, 44% decrease in AST level, and 33% decrease in ALK P along with the change of sleep apnea prevalence from 35% before surgery to 0% after 12 months. Weight loss by itself can cause a decrease in ALT level as it varies directly with BMI and waist circumference [41]. Uric acid is mostly produced in the liver from degradation of dieting and endogenously synthesized purine compounds. LRYGB can be an effective step in controlling the hyperuricemic conditions in patients suffering from obesity as a clinical disorder with purine and urate overproduction [42].

Our results show a decrease in SUI complaints from 12 cases to 1 case after the study period. A study on 101 morbidly obese women suggested that the effect of LRYGB on improving SUI is similar to corrective surgeries [43]. This could be explained by the decrease in chronic pressure on the pelvic diaphragm after weight loss and its consequential improvement in sphincter control. Changes in lifestyle are other factors involved in gaining better urinary continence.

Conclusion

LRYGB is an effective obesity surgery technique, with important metabolic and organic effects. It lowers the risk of chronic diseases such as DM, ischemic heart disease, and liver dysfunction as well as increasing quality of life by improving obesity comorbidities. LRYGB appears to be a safe and effective procedure with a low complication rate in Iranian morbidly obese patients. We suggest young age and male gender as positive factors for weight loss. Considering the HDL increase correlation with age LRYGB can potentially benefit a young male patient more than others.

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Conflicts of Interest All contributing authors (K.T., S.A., M.G., and H.A.) declare that they have no conflicts of interest.

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