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Effects of Laparoscopic Roux-en-Y Gastric Bypass on Anthropometric Characteristics, Hypertension, Type 2 Diabetes Mellitus and Metabolic Syndrome: An Iranian Experience

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Abstract

Background: Surgically induced weight loss is a treatment option for the management of obesity and the related common disorders. This study evaluated the beneficial effects of bariatric surgery on metabolic profile and the prevalence of metabolic syndrome (MetS) among Iranian patients. **Materials and Methods:** A prospective observational study was performed on 26 morbidly obese patients scheduled for bariatric surgery, using laparoscopic Roux-en-Y gastric bypass (LRYGB). The parameters of hypertension, type 2 diabetes mellitus (T2DM), hyperlipidemia, MetS prevalence, and anthropometric measurements of Iranian patients, were recorded, at the preoperative visit and in follow-ups. The follow-up was performed for a median of 12 months, and the change in MetS prevalence and its componnts were assesed**. Results:** LRYGB induced a mean weight loss of 69.0±21.2%, after 12 months. Preoperative MetS was diagnosed in 21 patients (84%) and decreased to 6 patients (24%) after LRYGB (P=0.001). Likewise, the prevalence of hypertension was significantly decreased from 76% (pre-LRYGB values) to 20% (post-LRYGB values) (P=0.001). The prevalence of T2DM was also decreased from 20% to 8% (P=0.5).**Conclusion: A**ccording to our results, RYGB produced a rapid and significant weight loss and improvement in hypertension and MetS within one year but there was a cont roversy about the improvement of T2DM, in Iranian morbidly obese patients.**[GMJ.2014;3(3):167-75]**

Keywords: Body Weight; Bariatric Surgery; Diabetes; Hypertension; Metabolic Syndrome; Obesity.

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Introduction

Obesity has become a major global concern around the world and is associated with mortality and also a wide variety of morbidities [1]. According to thereport of Kilpi and colleagues, obesity and future obesity-related diseases for nine countries in the Middle-East are growing in this region which requires governmental strategic planning for primary prevention of obesity [2]. In Iran as a developing country, the overall rate of obesity was reported about 20% and obesity is more frequent in women rather than men (30% vs. 17%) [3].

The association of obesity, particularly central obesity, and increasing risk of cardiovascular diseases and diabetes mellitus, hasbeen confirmed. This association leads to the concept of metabolic syndrome (MetS) which is a group of metabolic abnormalities including hypertension, dyslipidemia, abdominal obesity, and glucose intolerance [4]. Also, morbid obesity which defined as body mass index (BMI) greater than 40.0 kg/m2, is associated with MetS. There is a wide variety of treatment modalities for MetS, which will cause a decrease in morbidity and mortality indices of morbid obese patients. Lifestyle modification is the first step of MetS management but the bariatric surgery is shown to be the only sustainable and long-term effective treatment [6]. In addition, despite the variety of approaches and techniques for bariatric surgery, Roux-en-Y gastric bypass (RYGB) is the most effective bariatric surgery approach [7]. The RYGB is a combination of both restrictive and malabsorptive techniques. In this procedure, the surgeon creates a gastric pouch (25±5 ml), a 100 cm alimentary limb, a 60 cm biliopancreatic loop, and a common loop [8]. Laparoscopic adjustable gastric banding and laparoscopic Roux-en-Y gastric bypass (LRYGB) are two common types of bariatric surgery.

The prevalence of MetS in Iranian adults is higher than many countries [9], and according to the different responses indifferent ethnicities to weight loss strategies, in the present study we evaluated the impact of LRYGB induced weight loss on improvement of anthropometric characteristics, hypertension, type 2 diabetes Mellitus (T2DM), and also MetS.

Materials and Methods

Study Setting

This prospective study was performed on obese patients who were admitted for bariatric surgery, using LRYGB, referring to a private general hospital, Erfan Hospital, Tehran, Iran, between December 2009 and March 2010. The local Ethics Committee of Tehran University of Medical Sciences approved the study protocol. All patients gave their written informed consent prior to entering the study.

All patients with the age of 18-55 years old, BMI≥40 kg/m², and those with 35<BMI<40 kg/m² who had an obesity related comorbidity [10] were included. The patients with previously proved hepatic diseases (hemochromatosis, Wilson's disease, etc), consumer of more than 200 cc alcohol weekly, subjects with positive viral markers (HBsAg positive, anti-HCV Ab positive and anti-HIV Ab positive), positive antinuclear antibody (ANA) (≥1:160 cutoff), and those who were on medications that were related to fatty liver disease, such as tamoxifen, valproate, amiodarone, diltiazem, estrogens, corticosteroids, and methotrexate, were excluded.

Study Protocol

Anthropometric indices (waist circumstance, hip circumstance, height, and weight), blood pressure, and biochemical tests were recorded for all subjects, before bariatric surgery. Biochemical tests were fasting blood sugar (FBS), glycatedhaemoglobin or hemoglobin A1c (HbA1c), high-density lipoprotein (HDL), low-density lipoprotein (LDL), triglyceride (TG), total cholesterol, and uric acid. Blood samples were collected under 12 hours fasting conditions.

The operations were performed by a single surgeon. The surgeon used five-port technique for LRYGB surgery. Initially, in supine position, the greater omentum was dissected up to the transverse colon. Subsequently, the small intestine was transected about 35 cm down the Treitz 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, and then the trans-section was continued vertically to the angle of His. The gastrojejunostomy was made by end-to-side anastomosis and antecolicapproach [8].

We followed up the patients for 9 to 18 months after the surgery.Every month in post operative visits, the patients were evaluated with similar tests before the surgery. The last obtained anthropometric indices, physical examination and laboratory results were considered as follow-up results.

Medical Definitions

BMI was calculated as the weight (kilograms) divided by the square of the height (meters). Excess weight was calculated as preoperative weight minus ideal weight. Percentage of excess weight loss (EWL%) was calculated as [(preoperative weight−postoperative weight)/(preoperative weight−ideal weight)]×100 [11]. Diagnosis of MetS was made according to the International Diabetes Federation (IDF) definition (Central obesity plus any two of the following four factors: Hypertriglyceridemia (TG ≥ 150 mg/dL) or specific treatment for this lipid abnormality, low HDL levels (values < 40 mg/dL in males and < 50 mg/dL in females) or specific treatment for this lipid abnormality, systolic blood pressure (SBP)≥130 mmHg or diastolic blood pressure (DBP)≥85 mmHg or treatment of previously diagnosed hypertension, fasting plasma glucose≥100mg/dL or previously diagnosed T2DM [12]. According to the latest study on optimal cut-off points for the diagnosis of MetS in Iran, waist circumference of 90 cm was considered for both genders [13]. Normal values for uric acid were considered up to 7 mg/dL [10].

Statistical Analysis

The Statistical Package of Social Science version 16.0 (SPSS, Chicago, Illinois, USA) was used for data analysis. Student's Paired T-test and McNemar's test were used for comparison between operative measures for continuous and categorical variables, respectively. A two-sided P value less than 0.05 was considered as statistically significant for all tests. All Data are expressed as mean±SD.

Results

At first, twenty six morbidly obese patients were included. One patient excluded from the study because of diagnosis of new onset hepatitis C during follow-up visits. Finally, 25 patients including 20 females (80%) and five males (20%) with mean age of 35.0±10.9 years old recruited in the study. The patients were followed up for 9 to 18 months with the median follow-up duration of 12 months. The baseline characteristics and obesity related comorbidities of the patients are shown in Table-1.

The preoperative and postoperative changes in weight, anthropometric indices, metabolic parameters and MetS, hypertension and T2DM, were presented in Table-2.

Table 1. Baseline characteristics and obesity related comorbidities.

Characteristic	Value
Age (yr)	35.0 ± 10.9
Female/Male ratio	20/5
Weight (kg)	123.5 ± 30.2
Excess body weight (Kg)	55.3 ± 24.8
BMI (kg/m²)	44.9 ± 7.4
Waist circumferences (cm)	128.9 ± 20.3
Hip circumferences (cm)	143.2 ± 16.7
Hyperuricemia(n), %	4 (16%)
Hypertriglyceridemia (n), %	14 (56%)
Hypercholesterolemia (n), %	11 (44%)
Low HDL (n), %	16 (64%)
Metabolic syndrome (n), %	21 (84%)
Hypertension (n), %	19 (76%)
Diabetes Mellitus (n), %	5 (20%)

BMI: Body Mass Index

After LRYGB surgery, mean percentage of body weight loss (BWL), was 28.8 ± 8.2% (P < 0.001) and mean EWL% was 69.0 ± 21.2%. Before Surgery, mean plasma levels of HbA1c in diabetic patients were 7.0 ± 0.8% and have shown significant postoperative reduction, 5.7 ± 0.8% (P=0.003).

Postoperative changes in the prevalence of obesity related comorbidities, at the end of follow-ups, were represented in Table-2.

Before and after the surgery, respectively, four patients (16%) and 12 patients (48%) had two criteria of MetS, 10 patients (40%) and four patients (16%) had three criteria, seven patients (28%) and two patients (8%) had four, and four patients (16%) and two patients(8%), met complete five IDF criteria of MetS. The MetS significantly reduced after surgically induced weight loss (P=0.001). After surgery, five patients had only one criterion (20%) of MetS.

Discussion

The present study showed that weight loss induced by LRYGB improves hypertension, T2DM, metabolic parameters and also reduces the prevalence of MetS in morbidly obese patients.

By conventional treatments for obesity (diet therapy, exercise, behavioral modification, and drug induced weight loss) more than

Table 2. Preoperative and Postoperative Changes in Weight, Anthropometric Indices, Metabolic Parameters and the Prevalence of Obesity Related Comorbidities.

Metabolic Parameters	Before Surgery (Mean ± SD)	After surgery (Mean ± SD)	P value*
Weight (kg)	123.5 ± 30.2	86.9 ± 17.7	< 0.001
BMI (kg/m²)	44.9 ± 7.4	31.8 ± 4.8	< 0.001
Waist Circumference (cm)	128.9 ± 20.3	98.3 ± 11.8	< 0.001
Hip Circumference (cm)	143.2 ± 16.7	114.3 ± 11.3	< 0.001
SBP (mm Hg)	134.8 ± 19.7	121.5 ± 14.2	< 0.001
DBP (mm Hg)	84.3 ± 20.0	75.3 ± 10.2	0.005
FBS (mg/dL)	101.4 ± 13.5	91.5 ± 17.3	0.001
HbA1c	5.9 ± 0.8	5.3 ± 0.5	0.001
LDL Cholesterol (mg/dL)	110.3 ± 22.0	97.9 ± 14.5	0.016
HDL Cholesterol (mg/dL)	44.9 ± 7.3	49.4 ± 5.7	< 0.001
Triglyceride (mg/dL)	169.9 ± 78.9	138.9 ± 36.8	0.017
Total Cholesterol (mg/dL)	194.9 ± 33.6	164.6 ± 24.6	< 0.001
Prevalence of Obesity Related Comorbidities	**N (%)**	**N (%)**	**P value***
Metabolic Syndrome	21 (84%)	7 (28%)	0.001
Hypertension	19 (76%)	5 (20%)	0.001
Diabetes Mellitus	5 (20%)	2 (8%)	0.5
Hyperuricemia	4 (16%)	2 (8%)	0.625
Low HDL Cholesterol	16 (64%)	11 (44%)	0.125
Hypercholesterolemia	11 (44%)	3 (12%)	0.031
Hypertrigeliceridemia	14 (56%)	11 (44%)	0.625

BMI: body mass index; SBP: systolic blood pressure; DBP: diastolic blood pressure; FBS: fasting blood sugar, HbA1c:Hemoglobin A1c, LDL: low-density lipoprotein, HDL: high-density lipoprotein.

* P<0.05

95% of patients cannot maintain the optimal weight and any changes drop back to the previous weight in long-term [14-17]. Treatment of obesity should lead to achieve and maintain a clinically meaningful weight loss as well as reducing risk and severity of obesity related disorders and also reduced the metabolic impairments [18]. Bariatric surgery is the only long-term effective approach for weight loss in severely obese patients which provides improvement or complete resolution of obesity related comorbidities such as diabetes, hypertension, and dyslipidemia in many patients.Nowadays, Many surgeons consider the LRYGB to be the bariatric procedure of choice. [19].

Weight loss

Adequate BWL after LRYGB was reported from 35% after 6 months to 65% to 75% of EWL%, between 12 and 18 months postoperatively. Our results showed a reduction of 69.0% of EWL% in a median follow-up time of 12 months. DeMaria et al. reported 70% reduction of EWL% one year after LRYGB [20], and Higa et al. study showed 69% reduction of EWL% one year after LRYGB [21].
Another study reported excess BMI loss percentage of 72.2%, one year after LRYGB [22].

Metabolic syndrome

Prevalence of the MetS in obese people varies a lot mostly because of ethnicity differences [23]. Our data have shown the high prevalence of MetS among morbidly obese individuals from Iran, in comparison with other countries' studies [4, 24-26]. Recent studies appraise the higher prevalence of MetS in Middle-East region [27]. Prevalence of MetS in general population of Iran is 29% [13], which in our study, LRYGB caused a statistically significant reduction in prevalence of MetS from 84% to 28% of patients. In concert with our finding, Rossi et al. in a study on140 patients found a 42.8% decrease in MetS prevalence 6 months after LRYGB [24]. In a 12-months follow-up of twenty morbidly obese women after gastric banding, none of 11 patients diagnosed with MetS before surgery, met the criteria at the end of follow-up time [28].
In another study by Madan et al., on 53 patients with MetS who underwent a laparoscopic gastric bypass procedure, only one patient had MetS after one year follow-up [4].
In addition to overall obesity, central adiposity (or abdominal obesity) is an important cause of metabolic profile impairment and leads to raised blood pressure, raised fasting plasma glucose, and dyslipidemia, that characterize the MetS [29-30]. Several studies demonstrated that waist circumference and high level of visceral fat are strongly associated with deterioration of SBP, fasting and 2-hour postprandial plasma glucose, HDL, LDL, TG, and insulin resistance [31-32]. Previously, it has been presumed that improvements in the metabolic profile are a secondary consequence of the bariatric surgery, resulting from reduction in adiposity. However, recent observations of dramatic resolution of clinical and biochemical manifestations of MetS have given raise to the postulation of the hypothesis that the effects of bariatric operations are not only stemming from forced caloric restriction and weight reduction but more sophisticated neurohormonal mechanisms are also at work. Indeed, bariatric surgery is now believed to be a metabolic surgery [33-34].

Hypertension

Our results showed a 56% rate of resolution of high blood pressure after surgery. Along with our observations, several studies have demonstrated the effect of gastric bypass on normalizing blood pressure and specifically SBP in hypertensive obese patients in all age groups [35-36]. A meta-analysis by Buchwald et al. in 2004 demonstrated a 61.4% rate of resolution of high blood pressure and 78.5% improvement in high blood pressure after bariatric surgery [19]. In a study on 140 morbidly obese patients, the prevalence of high blood pressure reduced from 47.1% to 15%, just six months after LRYGB [37].A number of hormonal and anti-inflammatory pathways, induced by reduction of adipose tissue, have been considered to play role in normalizing the high blood pressure after bariatric surgery [38].

Diabetes mellitus and hyperglycemia

Resolution of T2DM after bariatric surgical

procedures has been subjected to expensive research in the past decade and generally, trials reported favorable rapid results. In the present study, 5 patients were diagnosed with T2DM before surgery, and although not statistically significant, but only two patients had T2DM postoperatively, at the end of follow-ups. The mean FBS level of patients significantly dropped from 101.4 to 91.5 mg/dL 12 months after LRYGB. In a meta-analysis of 22,094 morbidly obese patients, Buchwald et al. reported that T2DM was resolved in 77% of patients [19]. Moreover, in analysis of the bariatric outcomes longitudinal database in the United States, remission of diabetes occurred in 62.2% of patients diagnosed with MetS 12 months after gastric bypass [39]. Additionally, in a 5-year follow-up of 191 morbidly obese patients with T2DM or impaired fasting glucose, a significant decrease in fasting plasma glucose from 187 to 100 mg/dL was reported [40]. Probablyin the present study, our follow-up duration was short to find a significant reduction in prevalence ofT2DM.

The exact mechanisms responsible for glucosecontrol after bariatric surgery are not still clearly identified. The percentage of T2DM resolution is directly associated withpercentage of loss of excess body weight [41], however, T2DM can be resolved after intestinal surgery with minimal or no weight loss [42-43]. Of course, evidence suggests that alterations in the secretion of intestinal hormones play an important role in control of plasma glucose levels and resolution of T2DM after bariatric and metabolic procedures [33].

Dyslipidemia

The loss of weight, after bariatric surgery is accompanied by improvement of obesity related comorbidities including dyslipidemia [44]. Any techniques of gastric bypass procedure, breaks the enterohepatic cycle of cholesterol and biliary salts and increases the cholesterol synthesis and cholesterol turn over. Finally, there is a decrease in the plasma cholesterol levels [45]. In our study, 12 months after LRYGB, the prevalence of hypertriglyceridemia, hypercholesterolemia, and low HDL levels, decreased 12%, 32%, and 20%, respectively. Along with our results, a study of 140 morbidly obese individuals, showed a 39.3% decrease in hypercholesterolemia and 36.4% decrease in hypertriglyceridemia, after six months from LRYGB [24]. A meta-analysis in 2004 revealed a 79.3% overall improvement in dyslipidemic patients, following bariatric surgery [19]. According to bariatric outcomes longitudinal database, patients with MetS showed a 44.9% remission of dyslipidemia, after 12 months from gastric bypass [39].

Cardiovascular disease (CVD) is another related comorbidity of morbid obesity which the present study did not assess the impact of LRYGB on that. According to recent decade studies, increased inflammation could be considered to play a key rolein the pathophysiology of atherosclerosis and CVD and several large-scale studies have documented that C-reactive protein (CRP) is a strong independent predictor of future CVD and/or stroke and demonstrated that raised CRP in association with hyperinsulinemia is a risk factor for CVD [46,47]. According to Koppeet al., weight loss can decrease the insulin resistance and hyperinsulinemia; moreover,the decrease in BMI is associated with the decrease in CRP [48]. According to our knowledge, there was not any evaluation on the impact of LRYGB on the prevalence of CVD. It is seems valuable to considertheeffects of bariatric surgery on CRP levels and insulin resistance inmorbidly obese patients as the future studies.

Moreover the nutritional status, physical activity and the socioeconomic status of the patients was not considered in the present study. Mentioned criteria can modify the indices of postoperative MetS in morbid obese patients.

Conclusion

Our results suggest that LRYGB leads to a significant improvement in anthropometric measurements and metabolic profile of morbidly obese patients from Iran. The potential effect of bariatric surgery on resolution of metabolic disturbances canplay an important role in treatment of MetS and not only the morbid obesity. Longer follow-up is needed in order to evaluate the long-term effects of LRYGB on weight loss maintenance, the possibility of

weight regain, and also the improvement of metabolic profile.

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Conflict of Interest

The authors declare that there is no conflict of interest.

References

1. Olshansky SJ, Passaro DJ, Hershow RC, Layden J, Carnes BA, Brody J, et al. A potential decline in life expectancy in the United States in the 21st century. New Engl J Med. 2005;352(11):1138-45.
2. Kilpi F, Webber L, Musaigner A, Aitsi-Selmi A, Marsh T, Rtveladze K, et al. Alarming predictions for obesity and non-communicable diseases in the Middle East. Public Health Nutr. 2013:1-9.
3. Azizi F. Bariatric Surgery for Obesity and Diabetes. Arch Iran Med. 2013;16(3):182.
4. Ternovits CA, Tichansky DS. Metabolic syndrome: yet another co-morbidity gastric bypass helps cure. Surg Obes Relat Dis. 2006;2:48-51.
5. Pories WJ. Bariatric surgery: risks and rewards. J Clin Endocrinol Metab. 2008;93(11 Supplement 1):s89-s96.
6. Maggard MA, Shugarman LR, Suttorp M, Maglione M, Sugerman HJ, Sugarman H, et al. Meta-analysis: surgical treatment of obesity. Ann Intern Med. 2005;142(7):547.
7. Noria SF, Grantcharov T. Biological effects of bariatric surgery on obesity-related comorbidities. Can J Surg. 2013;56(1):47.
8. Jones KB, Afram JD, Benotti PN, Capella RF, Cooper CG, Flanagan L, et al. Open versus laparoscopic Roux-en-Y gastric bypass: a comparative study of over 25,000 open cases and the major laparoscopic bariatric reported series. Obes Surg. 2006;16(6):721-7.
9. Delavari A, Forouzanfar MH, Alikhani S, Sharifian A, Kelishadi R. First Nationwide Study of the Prevalence of the Metabolic Syndrome and Optimal Cutoff Points of Waist Circumference in the Middle East The National Survey of Risk Factors for Noncommunicable Diseases of Iran. Diabetes Care. 2009;32(6):1092-7.
10. National Heart L, Institute B. The practical guide: identification, evaluation, and treatment of overweight and obesity in adults. Bethesda, National Institutes of Health, NIH publication 00–4084.
11. Deitel M, Gawdat K, Melissas J. Reporting weight loss 2007. Obes Surg. 2007;17(5):565-8.
12. Alberti KG, Zimmet P, Shaw J. The metabolic syndrome-a new worldwide definition. Lancet. 2005;366(9491):1059-62.
13. Esteghamati A, Ashraf H, Rashidi A, Meysamie A. Waist circumference cut-off points for the diagnosis of metabolic syndrome in Iranian adults. Diabetes Res Clin Pr. 2008;82(1):104-7.
14. Pischon T, Boeing H, Hoffmann K, Bergmann M, Schulze M, Overvad K, et al. General and abdominal adiposity and risk of death in Europe. N Engl J Med. 2008;359(20):2105-20.
15. Hubert HB, Feinleib M, McNamara PM, Castelli WP. Obesity as an independent risk factor for cardiovascular disease: a 26-year follow-up of participants in the Framingham Heart Study. Circulation. 1983;67(5):968-77.
16. Avenell A, Brown T, McGee M, Campbell M, Grant A, Broom J, et al. What interventions should we add to weight reducing diets in adults with obesity? A systematic review of randomized controlled trials of adding drug therapy, exercise, behaviour therapy or combinations of these interventions. J Hum Nutr Diet. 2004;17(4):293-316.
17. Curioni C, Lourenco P. Long-term weight loss after diet and exercise: a systematic review. Int J Obes. 2005;29(10):1168-74.

18. Crea N, Pata G, Della Casa D, Minelli L, Maifredi G, Di Betta E, et al. Improvement of metabolic syndrome following intragastric balloon: 1 year follow-up analysis. Obes Surg. 2009;19(8):1084-8.
19. Buchwald H, Avidor Y, Braunwald E, Jensen MD, Pories W, Fahrbach K, et al. Bariatric surgery. JAMA. 2004;292(14):1724-37.
20. DeMaria EJ, Sugerman HJ, Kellum JM, Meador JG, Wolfe LG. Results of 281 consecutive total laparoscopic Roux-en-Y gastric bypasses to treat morbid obesity. Ann Surg. 2002;235(5):640.
21. Higa KD, Ho T, Boone KB. Laparoscopic Roux-en-Y gastric bypass: technique and 3-year follow-up. J Laparoendosc Adv Surg Tech A. 2001;11(6):377-82.
22. Toolabi K, Arefanian S, Golzarand M, Arefanian H. Effects of Laparoscopic Roux-en-Y Gastric Bypass (LRYGB) on Weight Loss and Biomarker Parameters in Morbidly Obese Patients: A 12-Month Follow-Up. Obes Surg. 2011:1-9.
23. Adami GF, Camerini GG, Ravera NS, Marinari GM. Metabolic syndrome in severely obese patients. Obes Surg. 2001;11(5):543-5.
24. Rossi M, Barretto Ferreira da Silva R, Chaves Alcantara G, Regina PF, Martin Bianco Rossi F, Serpa Neto A, et al. Remission of metabolic syndrome: a study of 140 patients six months after Roux-en-Y gastric bypass. Obes Surg. 2008;18(5):601-6.
25. Lee WJ, Huang MT, Wang W, Lin CM, Chen TC, Lai IR. Effects of obesity surgery on the metabolic syndrome. Arch Surg. 2004;139(10):1088.
26. Case C, Jones P, Nelson K, O'Brian Smith E, Ballantyne C. Impact of weight loss on the metabolic syndrome. Diabetes Obes Metab. 2002;4(6):407-14.
27. Ashraf H, Rashidi A, Noshad S, Khalilzadeh O, Esteghamati A. Epidemiology and risk factors of the cardiometabolic syndrome in the Middle East. Expert Rev Cardiovasc Ther. 2011;9(3):309-20.
28. Marantos G, Daskalakis M, Karkavitsas N, Matalliotakis I, Papadakis JA, Melissas J. Changes in metabolic profile and adipoinsular axis in morbidly obese premenopausal females treated with restrictive bariatric surgery. World J Surg. 2011;35(9):2022-30.
29. Cameron AJ, Boyko EJ, Sicree RA, Zimmet PZ, Söderberg S, Alberti KGMM, et al. Central obesity as a precursor to the metabolic syndrome in the AusDiab study and Mauritius. Obesity. 2008;16(12):2707-16.
30. Pouliot MC, Després JP, Nadeau A, Moorjani S, Prud'Homme D, Lupien PJ, et al. Visceral obesity in men: associations with glucose tolerance, plasma insulin, and lipoprotein levels. Diabetes. 1992;41(7):826-34.
31. Després JP, Moorjani S, Lupien PJ, Tremblay A, Nadeau A, Bouchard C. Regional distribution of body fat, plasma lipoproteins, and cardiovascular disease. Arterioscler Thromb Vasc Biol. 1990;10(4):497-511.
32. Poirier P, Després JP. Waist circumference, visceral obesity, and cardiovascular risk. J Cardiopulm Rehabil Prev. 2003;23(3):161-9.
33. Ikramuddin S, Buchwald H. How bariatric and metabolic operations control metabolic syndrome. Br J Surg. 2011;98(10):1339-41.
34. Folli F, Pontiroli AE, Schwesinger WH. Metabolic aspects of bariatric surgery. Med Clin North Am. 2007;91(3):393-414.
35. Maher JW, Martin HL, Pucci A, Wolfe LG, Meador JG, Kellum JM. Four hundred fifty consecutive laparoscopic Roux-en-Y gastric bypasses with no mortality and declining leak rates and lengths of stay in a bariatric training program. J Am Coll Surg. 2008;206(5):940.
36. Cunneen SA. Review of meta-analytic comparisons of bariatric surgery with a focus on laparoscopic adjustable gastric banding. Surg Obes Relat Dis. 2008;4(3):S47-S55.
37. Rossi M, Serpa Neto A, Rossi FMB, Amarante RDM, Alc ntara GC, da Silva RBF, et al. Percentage of excess BMI lost correlates better with improvement of metabolic syndrome after Roux-en-Y gastric bypass in morbidly obese subjects: anthropometric indexes and gastric bypass. Surg Obes Relat Dis. 2009;5(1):11-8.
38. Frezza EE, Wei C, Wachtel MS. Is Surgery the Next Answer to Treat Obesity-Related Hypertension? J Clin Hypertens (Greenwich). 2009;11(5):284-8.
39. Inabnet WB, Winegar DA, Sherif B, Sarr MG. Early outcomes of bariatric surgery in patients with metabolic syndrome: an analysis of the bariatric outcomes longitudinal database. J Am Coll Surg. 2012.
40. Schauer PR, Burguera B, Ikramuddin S, Cottam D, Gourash W, Hamad G, et al. Effect of laparoscopic Roux-en Y gastric bypass on type 2 diabetes mellitus. Ann Surg. 2003;238(4):467.
41. Buchwald H, Estok R, Fahrbach K, Banel D, Jensen MD, Pories WJ, et al. Weight and type

2 diabetes after bariatric surgery: systematic review and meta-analysis. Am J Med. 2009;122(3):248.
42. Cohen RV, Schiavon CA, Pinheiro JS, Correa JL, Rubino F. Duodenal-jejunal bypass for the treatment of type 2 diabetes in patients with body mass index of 22–34 kg/m2: a report of 2 cases. Surg Obes Relat Dis. 2007;3(2):195-7.
43. Bohdjalian A, Prager G, Aviv R, Policker S, Schindler K, Kretschmer S, et al. One-year experience with Tantalus™: a new surgical approach to treat morbid obesity. Obes Surg. 2006;16(5):627-34.
44. Weber M, Müller MK, Bucher T, Wildi S, Dindo D, Horber F, et al. Laparoscopic gastric bypass is superior to laparoscopic gastric banding for treatment of morbid obesity. Ann Surg. 2004;240(6):975.
45. Buchwald H, Moore RB, Varco RL. Surgical treatment of hyperlipidemia. 3. Clinical status of the partial ileal bypass operation. Circulation. 1974;49(5 Suppl):I22.
46. Ridker PM. Clinical application of C-reactive protein for cardiovascular disease detection and prevention. Circulation. 2003;107(3):363-9.
47. Esfahanian F, Zamani MM, Heshmat R, Moini nia F. Effect of Metformin compared with hypocaloric diet on serum C-reactive protein level and insulin resistance in obese and overweight women with polycystic ovary syndrome. J Obstet Gynaecol Res. 2013;39(4):806-13.
48. Kopp H-P, Kopp C, Festa A, Krzyzanowska K, Kriwanek S, Minar E, et al. Impact of weight loss on inflammatory proteins and their association with the insulin resistance syndrome in morbidly obese patients. Arterioscler Thromb Vasc Biol. 2003;23(6):1042-7.