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Assessment of Lipid Balance Parameters after Laparoscopic Sleeve Gastrectomy in 1-Year Observation

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Abstract: Introduction Currently, the increase in the percentage of obese people observed along with the development of civilization, reaching the level of a global pandemic, has forced the search for methods of effective and permanent obesity treatment. Obesity is a multifactorial disease, it coexists with many disease entities and requires multidisciplinary treatment. Obesity leads to metabolic changes in the form of metabolic syndrome, which includes, among others, atherogenic dyslipidemia. The proven relationship between dyslipidemia and cardiovascular risk enforces the need to effectively improve the lipid profile of obese patients. Laparoscopic sleeve gastrectomy is a method of surgical treatment of morbid obesity which improves bariatric and metabolic parameters. The aim of the study was to assess the effectiveness of laparoscopic sleeve gastrectomy (LSG) in improving lipid profile parameters in 1-year follow-up. **Material and Methods**: Bariatric parameters of 196 patients who underwent laparoscopic sleeve gastrectomy as well as lipid profile of total cholesterol (TC), high-density lipoprotein (HDL), low-density lipoprotein (LDL), non-NDL, and triglycerides (TG) in 1-year observation were analyzed. **Results:** Improvements in bariatric parameters were observed in patients after LSG. Total cholesterol, low-density lipoprotein (LDL), triglycerides and non-HDL levels decrease were observed along with the increase of high-density lipoprotein (HDL) cholesterol level. **Conclusions**: Sleeve gastrectomy is an effective method of treating obesity and improving the lipid profile in obese patients.

Keywords: obesity; sleeve gastrectomy; atherogenic dyslipidemia; lipid metabolism

Introduction

Currently, the observed increase in the incidence of obesity is caused by global development and progress in all areas of civilization, in particular economic, industrial, infrastructure, social and cultural. The prevalence of obesity in the last twenty years has reached the level of global pandemic and made it one of the main issues and directions of the activities of all world public health organizations and is treated as a civilization disease, with a huge socioeconomic and psychosocial importance [1]. Many years of research on obesity revealed its etiological and pathogenetic connection with many common diseases, such as: cardiovascular disease, including atherosclerosis, hypertension, insulin-dependent diabetes, dyslipidemia, obstructive sleep apnea, bone and joint disease, depression, some types of cancer, reproductive system and other [2, 3].

Understanding the relationship between obesity, and other frequent metabolic co-mobidities, led to the definition of a new disease entity – metabolic syndrome. Currently applicable criteria for recognizing metabolic syndrome adopted by the International Diabetes Federation (IDF) and American Heart Association/National Heart, Lung and Blood Institute (AHA // NHLBI) in 2009 include: abnormal waist circumference (depending on the population); triglyceride concentration (> 150mg/dl or the use of hypolipular treatment; HDL cholesterol fraction (<40 mg/dl (m), <50 mg/dl (K) or hypolipemic treatment used); arterial pressure (≥130/85 mm Hg or hypotensive treatment used);

fasting glycemia (≥100 mg/dl or hypoglycaemic treatment used). To recognize metabolic syndrome, 3 out of the 5 criteria [4] should be determined.

Analysis of the issues of pathological obesity and metabolic syndrome in terms of co-morbidity leads to the conclusion that they are a significant factor promoting the development of cardiovascular diseases, increasing the risk of the occurrence of myocardial infarction 2.5 - times, causing 1.5-times increase in total mortality and 2-times increase in the frequency of all cardiovascular incidents, including brain stroke [5]. The proven fact is that the spread of this syndrome in the world population is increasing and reaches levels that allow to treat it as a problem of public health and civilization disease [6]. The metabolic syndrome occurs in a world population with a frequency of about 20 to even 40%, depending on the analyzed region and/or ethnic group and the age of patients. The spread of MS has a tendency to grow in time and gives disturbing prognoses regarding the frequency of its occurrence in the future, is more common in women than in men, and its frequency increases significantly with age [7].

Lipid balance disorders are one of the main diseases coexisting with obesity and metabolic syndrome. Patients with abdominal obesity are more exposed to atherogenic dyslipidemia, which is associated with an increased risk of cardiovascular diseases with atherosclerotic disease and increased risk of morbidity and mortality due to cardiovascular disease [8, 9]. Research and treatment focus on improving in lipid profiles in the pursuit of a potential reduction of diseases related to the cardiovascular system. To diagnose dyslipidemia in the metabolic syndrome, it is required to find disorders of triglycerides and lipoproteins concentrations in patient plasma: TG ≥ 150 mg/dl and/or HDL <40 mg/dl (m), <50 mg/dl (k). However, in the course of obesity and metabolic syndrome, deviations in the concentration and functions of other lipids are also observed, such as an increase in the concentration of very low lipoproteins of VLDL and chylomikrone, as well as LDL.

The pathomechanism of the development of atherogenic dyslipidemia in the metabolic syndrome is closely associated with insulin resistance and excess of free fatty acids in the bloodstream. The accumulation of free fatty acids is the result of, among others, intensified in the course of insulin resistance, lipolysis and their lowered uptake at the level of adipocytes. The excess of free fatty acids results in their accumulation in the liver, reestrification to triglycerides and the intensified synthesis of TG -rich lipoprotein molecules with very low density VLDL [10]. At the same time, the influx of lipids supplied with food is higher in the case of insulin resistance than in healthy subjects, which results in postprandial hyperlipidemia phenomenon. Exogenous lipids enter the bloodstream in the form of chylomikrone molecules, produced in enterocytes. Postable hyperlipidemia is also closely related to changes in the course of insulin resistance, because chylomikrons and VLDL are used in the same metabolic pathways [11].

The third factor increasing triglyceridemia is the hepatic lipogenesis de novo, which does not inhibit in case of insulin resistance and results in TG [12] increases. Hypertriglyceridemia associated with high concentration of high VLDL-1 stimulates adverse, biochemical changes in HDL and LDL lipoproteins. The process of replacing cholesterol *esters with HDL and LDL for tri*glycerides from VLDL takes place through the c*holesteryl ester transfer protein* (CETP). As a result, the amount of cholesterol esters increases in VLDL, and the number of triglycerides increases in HDL and LDL. Furthermore, in the liver through the hepatic lipase, "small and dense" HDL and LDL [13] are created from these overloaded TG lipoprotein. Structurally abnormal HDL loses the possibility of cholesterol return transport from tissues (including blood vessels) to the liver, and also has a high plasma clearance, which is why it is quickly removed from the bloodstream and its concentration decreases. The small and dense LDL (SDLDL), on the other hand, has less affinity for receptors on hepatocytes than the normal LDL, which causes its longer maintenance in plasma [10].

Material and Methods

The aim of the study was to assess the effectiveness of LSG in the treatment of obesity, weight loss basing on BMI, %TWL, %EWL, %EBMI examined after 1, 3, 6 and 12 months of observation and assessment of LSG effectiveness in the treatment of dyslipidemia based on a change in total cholesterol, LDL, HDL, NI-HDL and triglycerides concentrations.

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Demographic, biometric and clinical data regarding patients from the study group were obtained prospectively on the day of surgery and as part of outpatient postoperative visits, which patients attended 1 month, 3 months, 6 months and 1 year after LSG. During these visits, blood samples were also taken in order to analyse laboratory and biochemical parameters.

Study group included 196 patients after laparoscopic sleeve gastrectomy in our Department in 2016-2020 with complete data gathered during 12-month postoperative observation. One hundred and seven men (54.6%) and 89 women (45.4%) were included in the study. The average age of patients in the study group was 44.9 years, the youngest patient was 21 years old, and the oldest 66 years old. The median BMI value on the day of the operation was 47.7 kg/m^2.

Statistical analysis: Collected data was analyzed using STATA 13.0 software. Measurable variables observed in the study group for individual parameters subjected to statistical analysis are presented as average with standard deviations (SD) or as a median with interquartile intervals, in regard to a case. Statistical comparisons of measurable variables were conducted using repetitive measurements with a Wilcoxon test with multiple comparison of post-hoc variables. Pearson's coefficient was used to evaluate the correlation of variables. Analyzed variables were considered statistically significant at the level of significance $p \leq 0.05$.

Results

The weight reduction rate as a result of LSG, analyzed on the basis of changes in bariatric parameters in the intervals of postoperative observation is presented in Table 1 (Table 1). The results of body weight reduction analysis observed after laparoscopic sleeve gastectomy. At the end of the 1-year follow-up, the median BMI in the study group was 33.4 kg/m^2.

	Before the surgery	1 month		3 months		6 months		12 months	
		Mean +/-	p	Mean +/-	P	Mean +/-	p	Mean +/-	p
Body mass [kg] (SD)	145.7 (120.6-170.7)	129.3 (106.7-152.0)	0.0000	117.4 (96.3-138.5)	0.0000	106.5 (85.7-127.4)	0.0000	101.4 (80.8-122.0)	0.0000
BMI [kg/m^2] (SD)	48.3 (41.5-55.1)	42.9 (36.6-49.3)	0.0000	39 (32.9-45.1)	0.0000	35.4 (29.3-41.4)	0.0000	33.7 (27.6-39.7)	0.0000
%EBL (SD)		24.3 (17.7-30.9)	0.0000	(42.2 (31.4-52.9)	0.0000	58.4 (43.7-73.2)	0.0000	66.0 (48.5-83.5)	0.0000
%EWL (SD)		21.6 (16.1-27.1)	0.0000	37.5 (28.7-46.3)	0.0000	51.9 (39.7-64.2)	0.0000	58.7 (44.1-73.3)	0.0000
%TWL (SD)		11.2 (8.7-13.7)	0.0000	19.5 (15.8-23.1)	0.0000	27.0 (21.8-32.2)	0.0000	30.5 (24.2-36.8)	0.0000

The dynamics of weight loss in the group was similar in the observation intervals between 0 and 1 month, 1 and 3 months and 3 and 6 months, while in the interval between 6 and 12 months it slightly deccelerated. Throughout the postoperative observation, a positive trend was maintained in body weight reduction, which was expressed in negative trend of mean BMI values and positive trends in an increase in percentage values %TWL, %EWL and %EBL. Operated patients within 1 year after the procedure lost an average of about 1/3 of their total, initial body weight, which accounted for about 66% of their excess BMI resulting from obesity.

Furthermore, the plasma lipidogram was analyzed. For this purpose, repetitive determinations were conducted of total cholesterol (TC), triglycerides (TG), high density lipoprotein (HDL-C), low density lipoprotein (LDL-C) and the level of all lipoproteins associated with AP-B (so-called HDL = TC-HDL-C) during the follow-up visits of patients in the 1st, 3rd, 6th and 12th month after laparoscopic sleeve surgery.

The final determinations of plasma lipid profile of patients undergoing LSG surgery after 1 year from the procedure showed the average TC concentration in a group of 175.9 mg/dl, so it decreased

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by 16.6 mg/dl in relation to preoperative value. The level of LDL-C fraction finally reached an average of 109.3 mg/dl, i.e. it was 14.5 mg/dl lower than preoperative.

The average TG concentration in plasma significantly decreased from 148.6 mg/dl to 117.5 mg/dl. However, the average concentration of high density lipoprotein fraction increased to 58.3 mg/dl, and at the end of the observation it was 14.3 mg/dl higher than before LSG. The level of non-HDL lipoproteins in the plasma of examined patients at the end of the observation was 117.5 mg/dl and it was lower than the initial value by 31.1 mg/dl. All changes observed in this group of patients in the lipid balance parameters after 12 months were statistically significant ($p < 0.05$). The aforementioned changes in the lipid profile of patients after LSG are presented in Table 2 and Charts 1.

	Before the surgery	1 month		3 months		6 months		12 months	
		Mean +/-	p	Mean +/-	P	Mean +/-	p	Mean +/-	p
TC [mg/dl] (SD)	192.5 (154.7-230.4)	170.5 (134.3-206.7)	0.0000	172.1 (143.4-200.9)	0.0000	175.0 (144.6-205.5)	0.0000	175.9 (141.9-209.9)	0.0000
LDL [mg/dl] (SD)	123.8 (92.6-155.0)	115.2 (82.9-147.5)	0.0000	114.0 (88.1-139.8)	0.0000	116.7 (87.5-145.9)	0.0032	109.3 (76.3-142.2)	0.0000
HDL[mg/dl] (SD)	44.0 (35.3-52.7)	36.8 (29.9-43.6)	0.0000	43.0 (35.5-50.4)	0.0486	49.9 (39.2-60.5)	0.0000	58.3 (42.8-73.8)	0.0000
Nie-HDL [mg/dl] (SD)	148,6 (110,8-186,3)	133,7 (97,2-170,2)	0,0000	129,2 (101,0-157.4)	0,0000	125,2 (94,1-156,3)	0,0000	117,5 (82,2-152,9)	0,0000
TG [mg/dl] (SD)	169.1 (74.2-264.0)	146.3 (95.5-197.1)	0.0013	123.8 (83.8-163.9)	0.0000	109.9 (66.0-153.7)	0.0000	101.7 (54.2-149.2)	0.0000

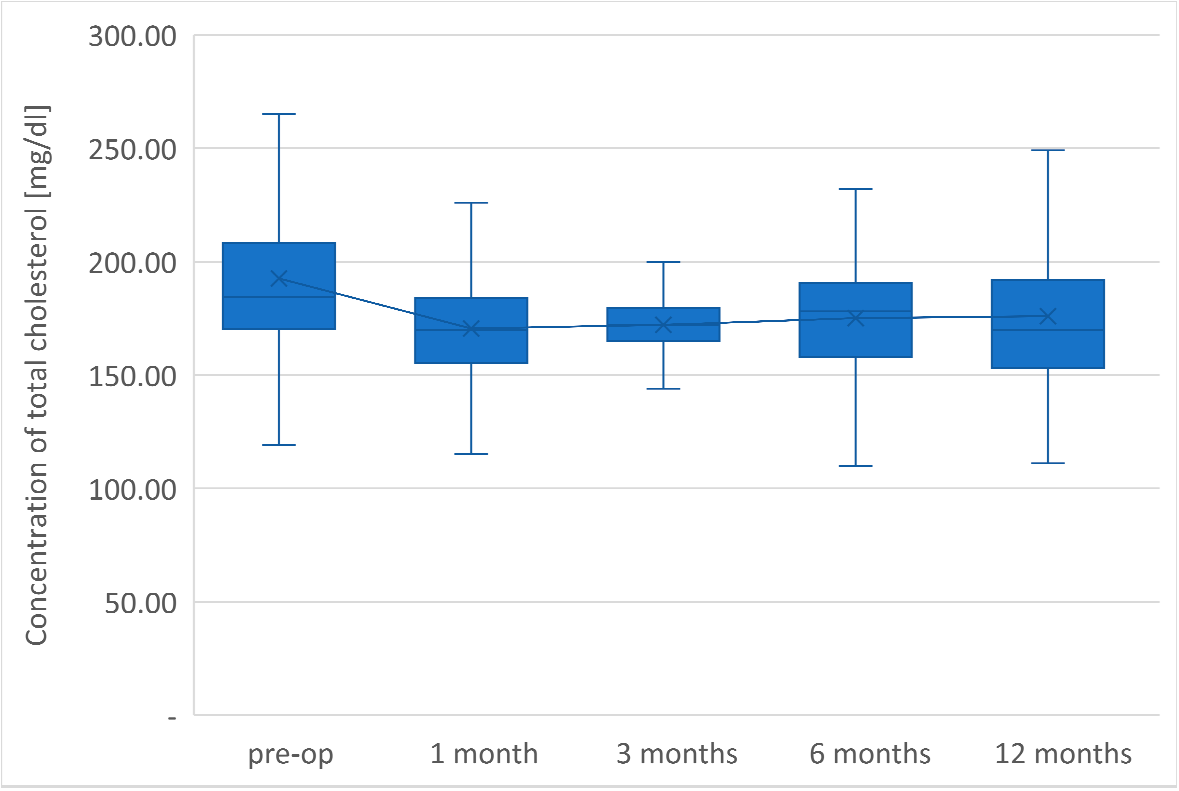

Chart 1. Changes of concentration of total cholesterol after LSG in 12-months follow-up.

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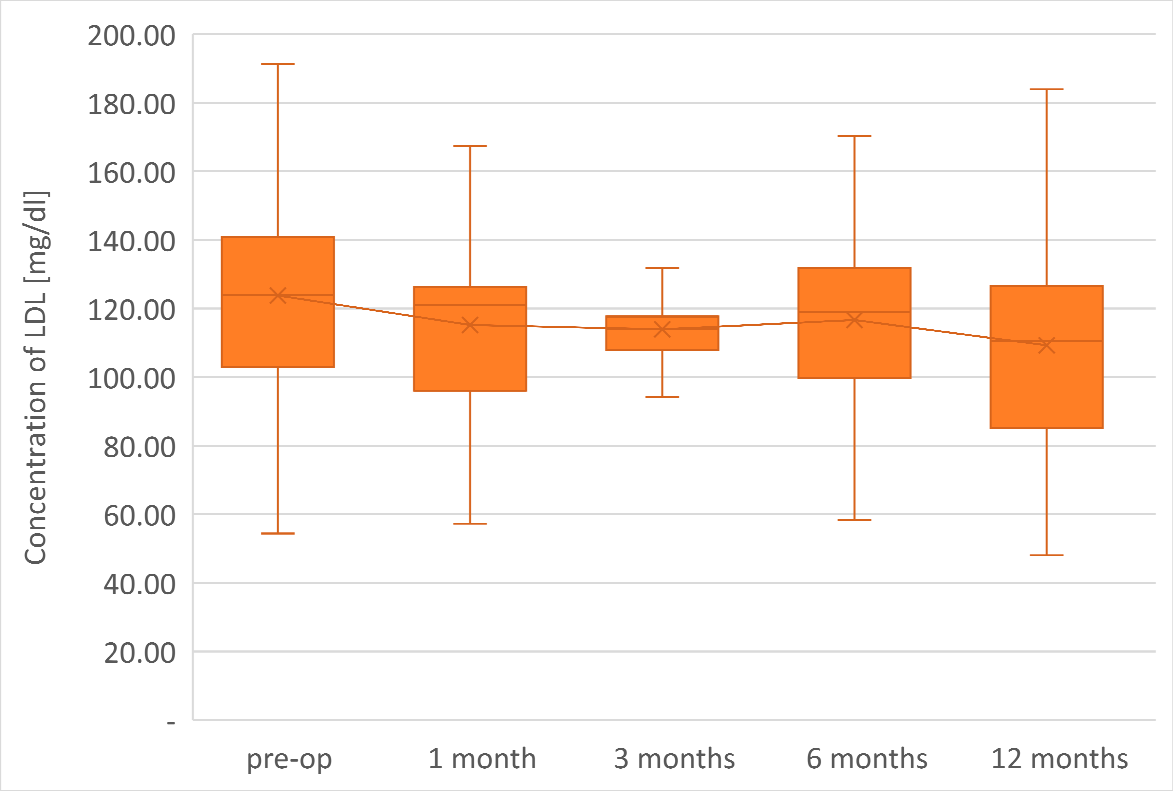

Chart 2. Changes of concentration of LDL after LSG in 12-months follow-up.

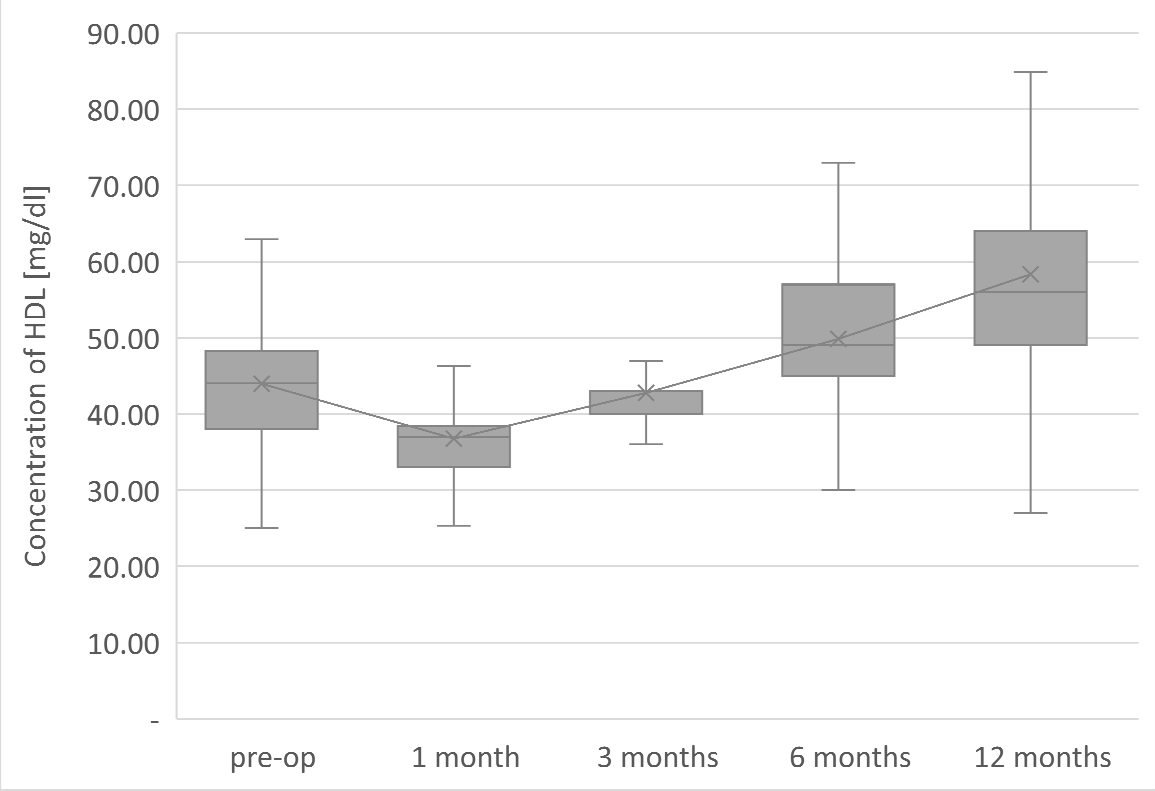

Chart 3. Changes of concentration of HDL after LSG in 12-months follow-up.

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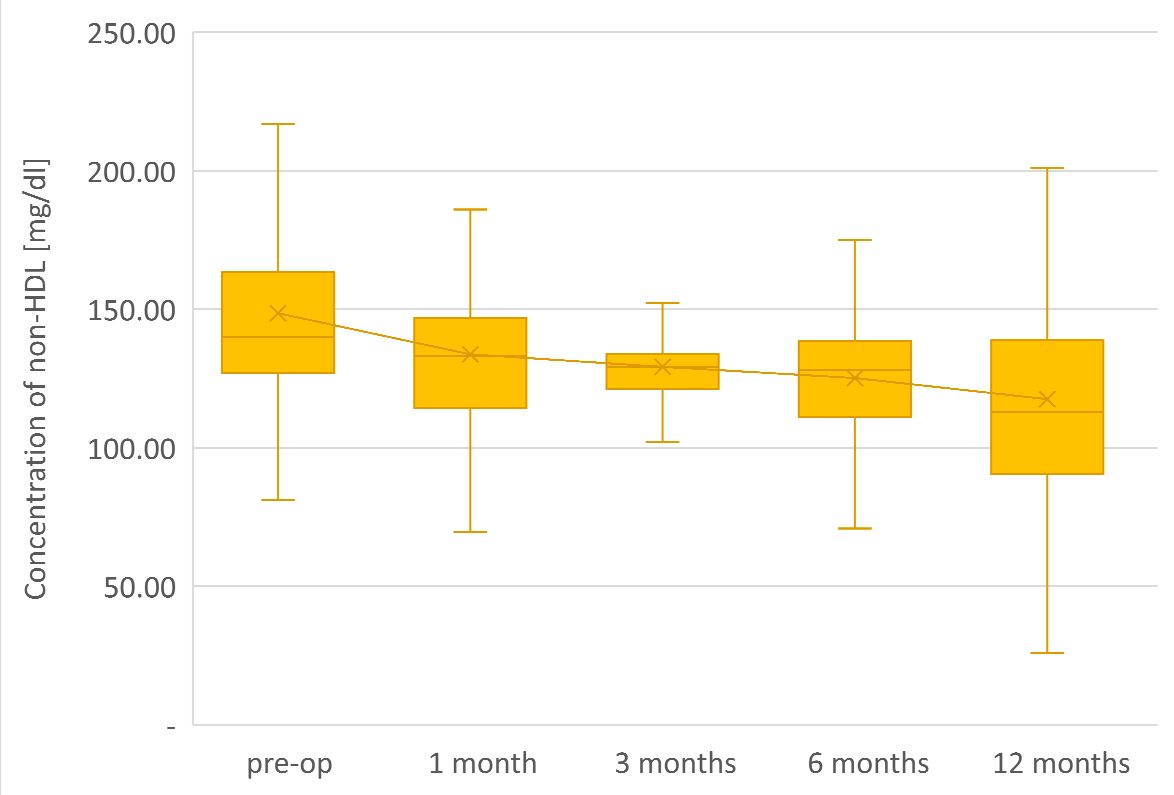

Chart 4. Changes of concentration of non-HDL after LSG in 12-months follow-up.

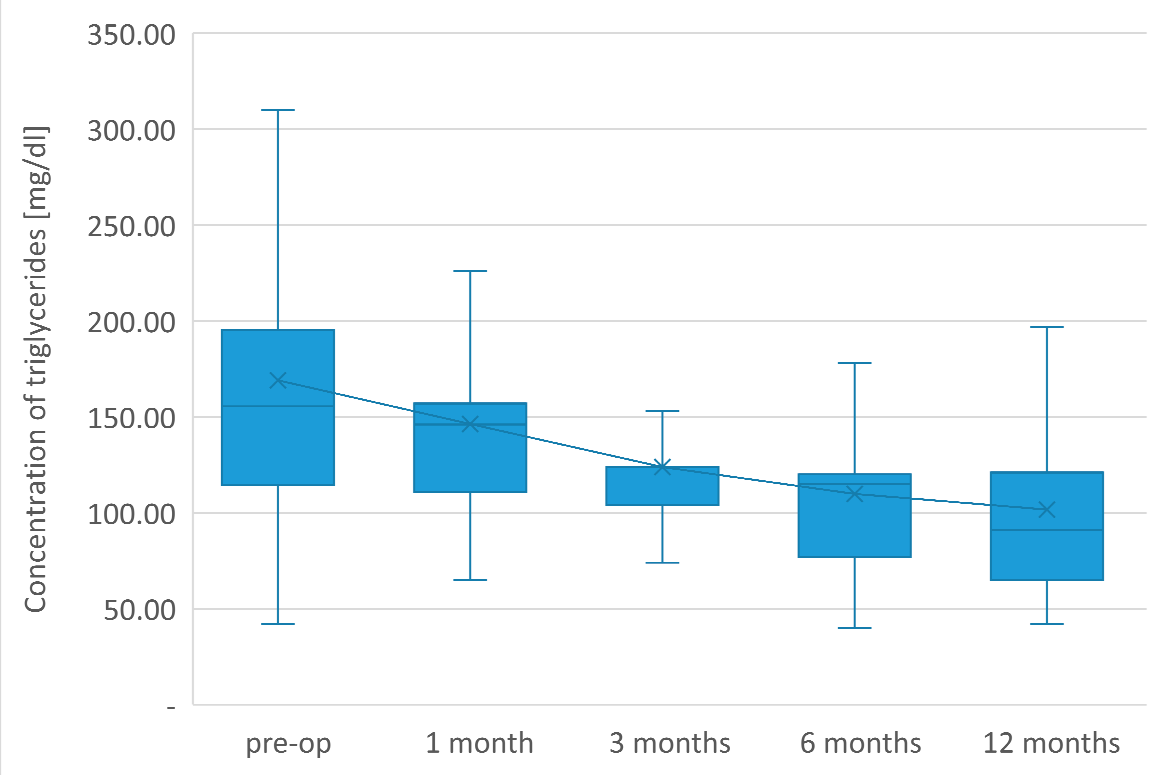

Chart 5. Changes of concentration of triglycerides after LSG in 12-months follow-up.

The correlation between changes in concentrations of total cholesterol and LDL, HDL, NI-HDL and triglycerides with bariatric results obtained after 12 months after the surgery BMI, %EWL, %EBL, %EBL, %TWL was examined (Table 3, Charts 6–25). No correlation was observed between bariatric

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results and change in total cholesterol, low density lipoproteines LDL, non-HDL, or triglycerides. Correlation between BMI and %EWL and %EBL 12 months after surgery and a change in high density lipoprotein concentration were demonstrated. p <0.05 was recognized as the level of statistical significance.

	ΔTC	ΔLDL	ΔHDL	Δnon-HDL	ΔTG
BMI	R^2=0.0001 p=0.8793	R^2=0.0022 p=0.5171	R^2=0.218 p=0.0389	R^2=0.019 p=0.5482	R^2=0.0069 p=0.2485
%EBL	R^2=0.0024 p=0.4987	R^2=0.0006 p=0.7329	R^2=0.0245 p=0.0284	R^2=0.0001 p=0.8919	R^2=0.0000 p=0.9414
%EWL	R^2=0.0028 p=0.4622	R^2=0.0003 p=0.8081	R^2=0.0213 p=0.0413	R^2=0.0000 p=0.9798	R^2=0.0003 p=0.8132
%TWL	R^2=0.0045 p=0.3496	R^2=0.0010 p=0.6661	R^2=0.0073 p=0.2352	R^2=0.0012 p=0.6340	R^2=0.0112 p=0.1405

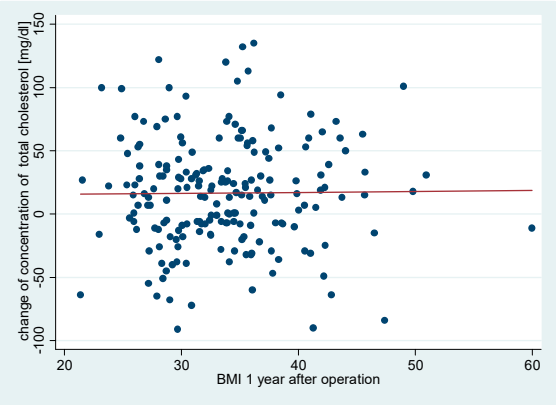

Chart 6. Correlation between changes of concentration of total cholesterol with BMI 1 year after LSG.

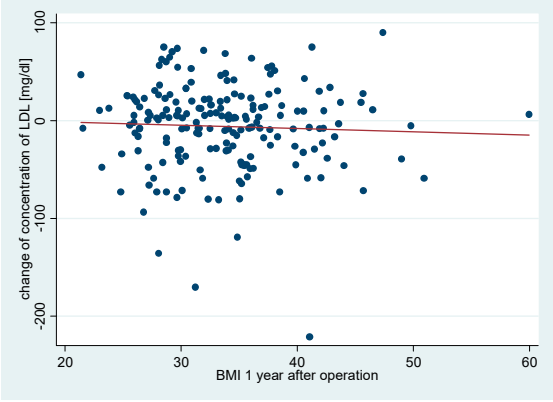

Chart 7. Correlation between changes of concentration of LDL with BMI 1 year after LSG.

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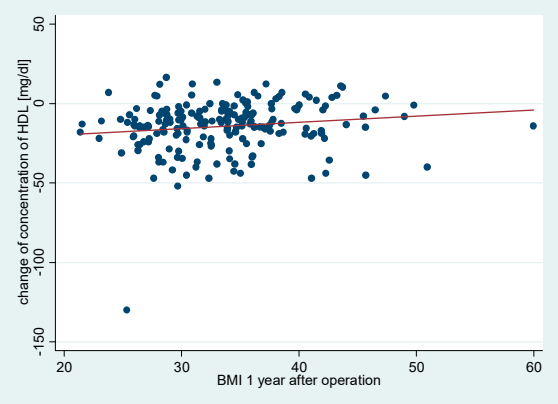

Chart 8. Correlation between changes of concentration of HDL with BMI 1 year after LSG.

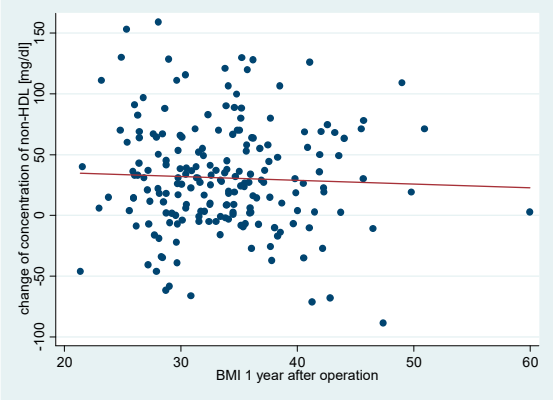

Chart 9. Correlation between changes of concentration of non-HDL with BMI 1 year after LSG.

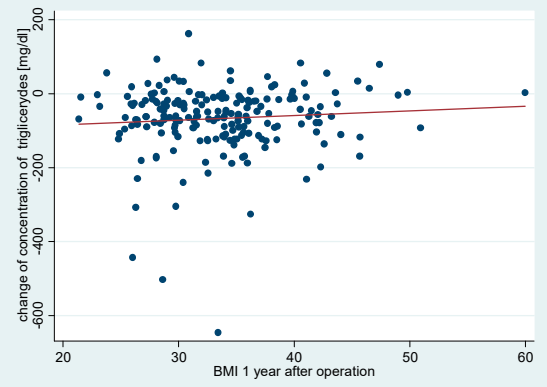

Chart 10. Correlation between changes of concentration of triglycerides with BMI 1 year after LSG.

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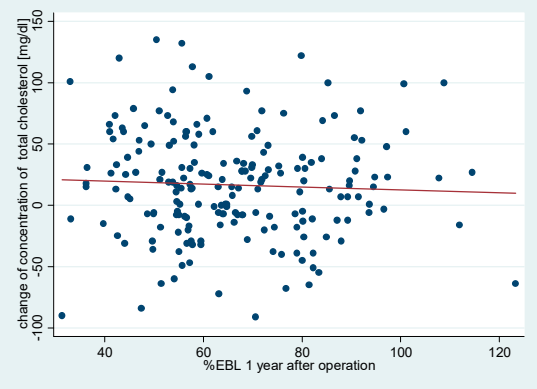

Chart 11. Correlation between changes of concentration of total cholesterol with %EBL 1 year after LSG.

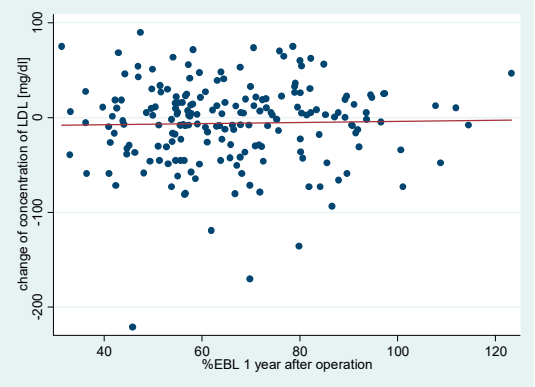

Chart 12. Correlation between changes of concentration of LDL with %EBL 1 year after LSG.

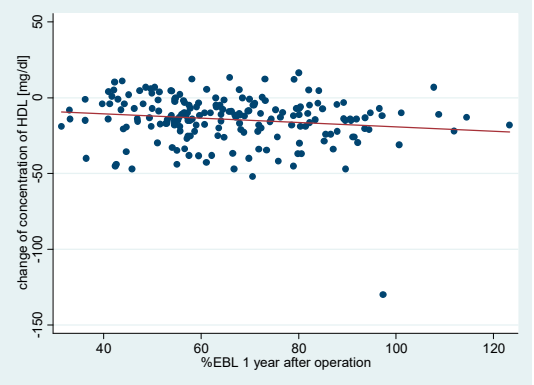

Chart 13. Correlation between changes of concentration of HDL with %EBL 1 year after LSG.

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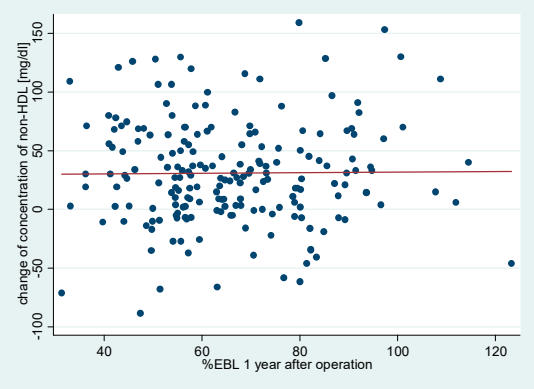

Chart 14. Correlation between changes of concentration of non-HDL with %EBL 1 year after LSG.

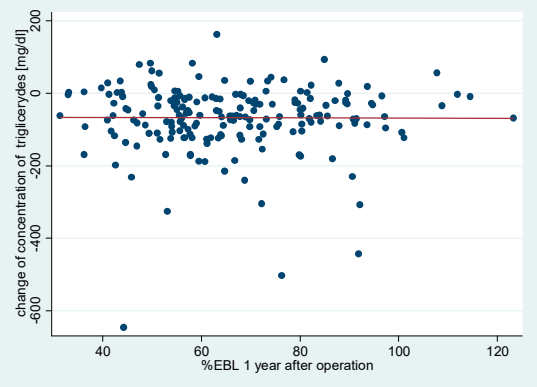

Chart 15. Correlation between changes of concentration of triglycerides with %EBL 1 year after LSG.

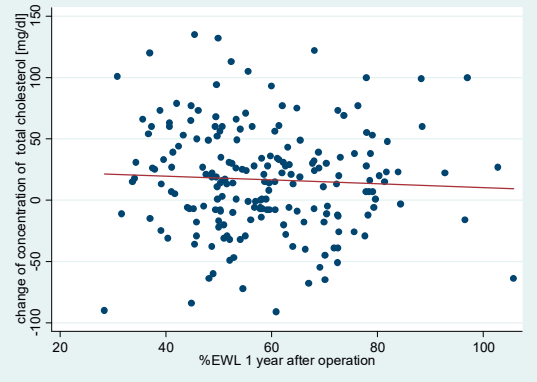

Chart 16. Correlation between changes of concentration of total cholesterol with %EWL 1 year after LSG.

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Chart 17. Correlation between changes of concentration of LDL with %EWL 1 year after LSG.

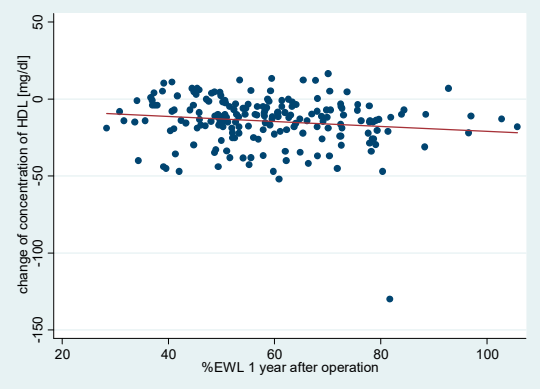

Chart 18. Correlation between changes of concentration of HDL with %EWL 1 year after LSG.

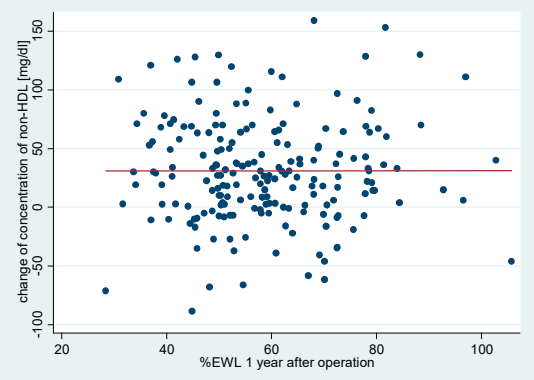

Chart 19. Correlation between changes of concentration of non-HDL with %EWL 1 year after LSG.

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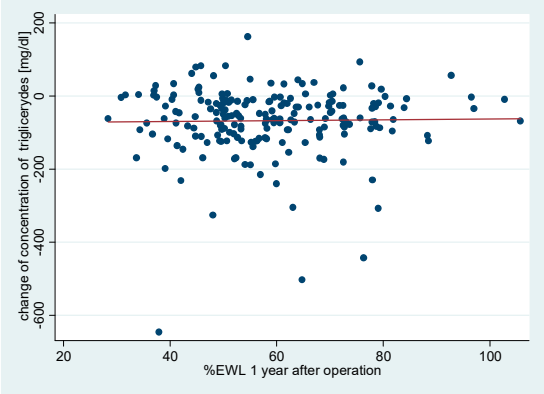

Chart 20. Correlation between changes of concentration of triglycerides with %EWL 1 year after LSG.

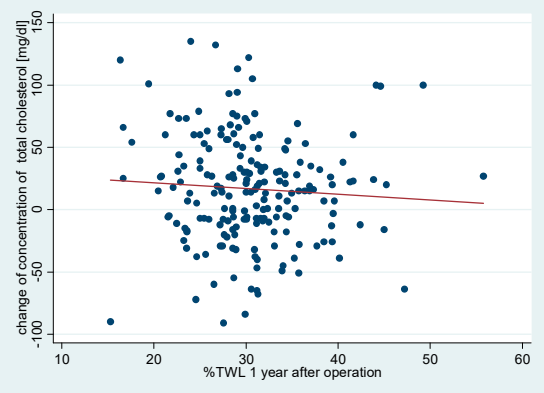

Chart 21. Correlation between changes of concentration of total cholesterol with %TWL 1 year after LSG.

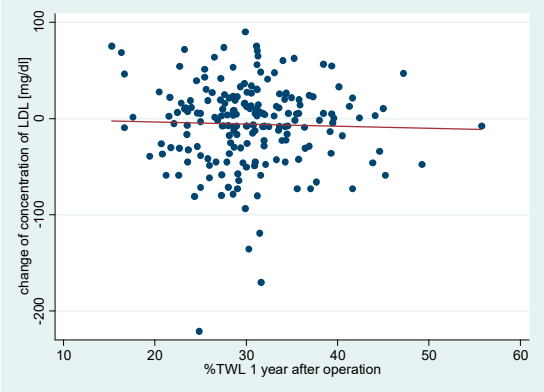

Chart 22. Correlation between changes of concentration of LDL with %TWL 1 year after LSG.

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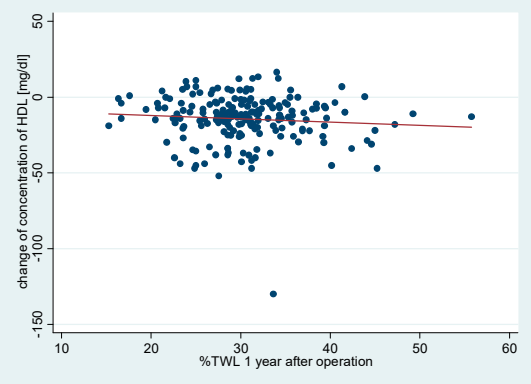

Chart 23. Correlation between changes of concentration of HDL with %TWL 1 year after LSG.

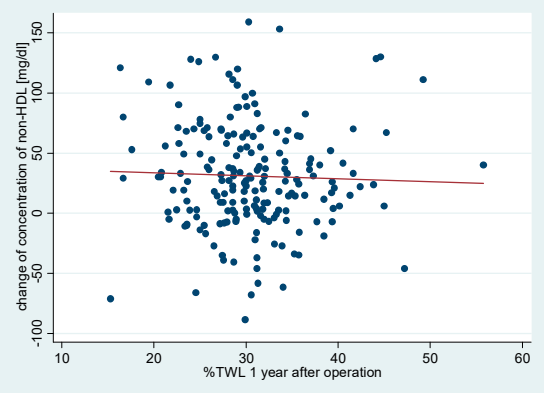

Chart 24. Correlation between changes of concentration of non-HDL with %TWL 1 year after LSG.

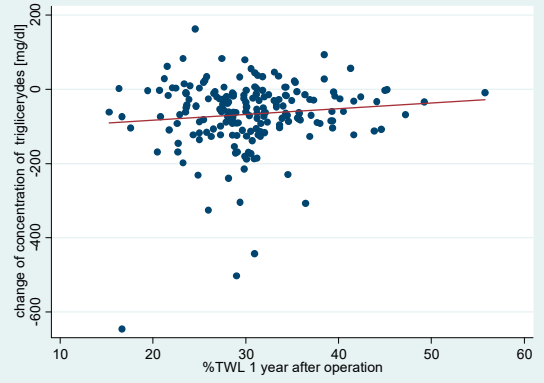

Chart 25. Correlation between changes of concentration of triglycerides with %TWL 1 year after LSG.

Discussion

Obesity is undoubtedly one of the largest problems of modern health care. According to The World Obesity Federation, 1 billion population will live with obesity in 2030 [14]. The scale of the problem forces to look for effective methods of preventing and treating obesity and coexisting diseases to reduce the morbidity and mortality associated with obesity.

Presented results of the 1-year observation of patients after sleeve gastrectomy confirm the effectiveness of surgery in the treatment of obesity and weight reduction. Considering the confirmed close relationship of body mass and obesity with comorbidity and mortality, statistically significant

decrease in body weight and BMI after surgery lead to conclusion on indisputable health benefits after laparoscopic sleeve gastrectomy [14,15]. Available review and research publications analyzing the subject of postoperative weight loss, BMI, %TWL, %EWL, %EBL after LSG were in line with the results obtained in our study [16,17]. Sleeve gastectomy is considered an effective and safe method of treating obesity [18, 19].

The parameter of the assessment of changes in patient's lipid profile after the surgery was observed in the control points of the TC, TG, HDL, LDL and NI-HDL lipid fractions. Analysis of changes in the above lipidogram parameters among patients undergoing laparoscopic sleeve gastrectomy after 1, 3, 6 and 12 months of postoperative control showed different, non-linear variations of the average concentrations of individual fractions in the group, however, the final effect of the procedure obtained after 1 year of observation was a reduction in the average atherogenic levels of lipids, i.e. TC, TG, LDL-C and NI-HDL, which was accompanied by a simultaneous increase in the level of antiatherosclerotic HDL-C lipoprotein.

Such clinically beneficial characteristics of changes in the lipid profile occurring after bariatric procedures is also described by many other authors studying the issue [20, 21, 22]. Regading the average concentration of HDL-C lipid fractions and triglycerides in the plasma of analyzed patients obtained at the end of the observation tand the criteria for diagnosing metabolic syndrome, it should be noticed that the decrease of TG level below the threshold value of 150 mg/dl was obtained, however, the concentration of HDL-C incrased above the desired 50 mg/dl, so this procedure proved to be effective in the treatment of dyslipidemia defined by the criteria of the metabolic syndrome.

In the assessment of cardiovascular risk, researchers and clinical practice take into account the treatment of atherogenic dyslipidemia, based mainly on reduction of low-density fraction of LDL cholesterol. Scientific research confirms that the reduction of LDL fraction correlates most closely with reducing cardiovascular risk [23]. Scientific data is available indicating the role of non-HDL as an alternative therapeutic determinant in the assessment of CVD risk, as covering all fractions containing apoB with stronger correlation with CDV risk tham LDL concentration in patients with high TG concentration in patients who were not fasting at time of examination. Non-HDL may be considered an alternative therapeutic goal in the treatment of dyslipidemia and prevention of cardiovascular diseases, but it is not widely used [24]. In connection with the above, a beneficial effect of bariatric operations may be observed in CVD risk reduction based on changes in the lipid profile in the form of a decrease in LDL.

Atherogenic properties of lipoproteins rich in TG is widely proved [25]. Some authors indicate the significant importance of hypertriglyceridemia and low HDL levels on the increase in cardiovascular risk. Although genetic evidence indicated triglycerides (TG) in plasma as an independent risk factor of CVD, no consensus has been achieved as to the targeting of the elevated level of these lipoproteins to prevent CVD [25].

Conclusions

Laparoscopic sleeve gastrectomy is an effective method of morbid obesity treatment, and its effects are permanent. It is safe and low risk of complications is observed regardig this method.

Sleeve gastrectomy improves lipid profile independently of weight loss, reducing the concentration of total cholesterol, LDL, non-HDL, triglycerides and increasing HDL concentration. Therapeutic effect is observed in lipid fractions, the concentrations of which are taken into account in diagnostics of MS.

The correlation of bariatric effects with a change in high density lipoproteins was proved. No such correlations were observed in other lipid fractions.

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