The effect of bariatric procedures on selected laboratory parameters of patients from rural areas in Poland

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Abstract

Background. Rural areas in Poland are inhabited by over 15 million people, i.e. 39.5% of Polish population, including about 5 million rural residents in the Podlaskie province. The incidence of obesity is associated with increased prevalence of obesity-related conditions. Studies that have been conducted do not confirm the efficacy of conservative treatment of obesity, but show that bariatric procedures produce the best long-term results.

Objectives. The aim of the study was to present the effects of bariatric obesity treatments (laparoscopic adjustable gastric banding [LAGB], sleeve gastrectomy [SG], Roux-en-Y gastric bypass [RYGB]) on body mass index (BMI), selected diabetes control parameters, dyslipidemia, hepatic and renal enzymes, blood count and hypertension control.

Material and methods. The study group comprised a total of 100 consecutive patients from rural areas qualified for bariatric procedures. Most of the patients (69.07%) underwent SG; 11.34% underwent LAGB; and 19.59% underwent RYGB. Comorbidities included hypertension (35%), type 2 diabetes (52%) and hyperlipidemia (15%). Glucose, insulin, HbA1C, alanine and aspartate aminotransferase, bilirubin, total and fraction cholesterol, creatinine, urea, uric acid and CRP levels, as well as blood count and blood pressure values, were assessed prior to surgery and during follow-up visits 3 and 6 months after the procedures. BMI, percentage of excess weight loss (%EWL) and percentage of excess body mass index loss (%EBMIL) were assessed.

Results. Consistent, significant decreases in BMI were observed 3 months (39.31 \pm 4.70) and 6 months (35.74 \pm 4.52) after surgery. The largest BMI reduction at the 6-month follow up was observed for SG (12.29%), and the smallest was observed for LAGB (9.02%).

Conclusions. Improvements in the general health status of the patients were observed, as well as normalization of metabolic parameters (glucose, cholesterol, triglycerides, hepatic enzymes).

Key words: obesity, bariatric surgery, remission, rural population, type 2 diabetes mellitus

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Obesity is a multifactorial, progressive disease characterized by an excessive accumulation of adipose tissue. According to the World Health Organization (WHO), the number of patients with obesity has increased globally, with a body mass index (BMI) > 40 kg/m² found in 400 million people. Polish studies published in 2011 by the Central Statistical Office showed that obesity affects 16.4% of the adult Polish population. The incidence of overweight and obesity is similar in urban and rural areas. Rural areas of Poland are inhabited by over 15 million people, i.e. 39.5% of the Polish population, including about 5 million rural residents in the Podlaskie province. 3.4

The incidence of obesity is associated with increased prevalence of obesity-related conditions (e.g. type 2 diabetes, hypertension, hyperlipidemia, heart diseases, stroke, asthma, degenerative diseases of the spine, obstructive sleep apnea, depression). A shorter life expectancy (by about 20 years) as well as increased mortality confirm the extent of the problems in this group of patients. Management of patients with obesity requires cooperation among many specialists, including cardiologists, internists, diabetologists, psychiatrists and surgeons. ^{5,6} Studies that have been conducted do not confirm the efficacy of conservative treatment, but show that bariatric procedures produce the best long-term results. ⁷

The current European recommendations for the surgical treatment of obesity indicate that a number of different techniques are available. Restrictive techniques involve a reduction in gastric capacity, limiting the amount of ingested food. The most common procedures include laparoscopic adjustable gastric banding (LAGB); vertical banded gastroplasty (VBG); and sleeve gastrectomy (SG). Methods for limiting absorption from the gastrointestinal tract reduce the duration of the digestion process, which results in fewer calories and nutrients being absorbed by

the body. These procedures include jejunoileal intestinal bypass (JIB); biliopancreatic diversion (BPD); and duodenojejunal bypass (DJB). Combination techniques, such as Roux-en-Y gastric bypass (RYGB) and biliary pancreatic diversion with duodenal switch surgery (BPD/DS), reduce both the amount of food and the number of calories absorbed as a result of GI tract modification. ^{8,9}

Although the efficacy of bariatric procedures for obesity and concomitant disease control is supported by a number of studies, assessment of the role of these surgical techniques is insufficient. The prevalence and consequences of obesity in rural areas have been assessed in only a few studies worldwide.^{10–13}

The aim of this study was to present the effects of bariatric obesity treatment (LAGB, SG and RYGB) on BMI, selected diabetes control parameters, dyslipidemia, hepatic and renal enzymes, blood count and hypertension control.

Material and methods

The study group comprised a total of 100 consecutive patients from rural areas (with up to 5,000 inhabitants) who qualified for bariatric procedures at the Medical University of Bialystok Clinical Hospital (Białystok, Poland) between January 2013 and December 2014. Two patients decided against undergoing surgery. The study group included 29 men (mean age 49 ± 11.4) and 71 women (mean age 45 ± 11.2). The patients' BMI was calculated during their first visit to qualify for surgery. The mean preoperative BMI was 47.15 ± 5.51 kg/m², and mean body weight was 132.21 kg.

In 72% of the patients, health problems were the reason for seeking bariatric surgery. Comorbidities included

Table 1.	Weight	reduction	parameters
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Parameters	LAGB med. ± SD	SG med. ± SD	RYGB med. ± SD	Total med. ± SD	p-value
BMI (kg/m²) before surgery	43.41 ± 3.40	48.55 ± 5.52	44.95 ± 4.21	47.26 ± 5.42	*
BMI (kg/m²) 3 months after surgery	37.26 ± 3.78	40.10 ± 4.77	37.69 ± 4.36	39.31 ± 4.70	type of surgery $-p = 0.0164$ time since surgery
BMI (kg/m²) 6 months after surgery	34.39 ± 3.49	36.26 ± 4.78	34.71 ± 3.92	35.74 ± 4.52	– p < 0.0001
% EWL 3 months after surgery	30.36 ± 11.14	33.52 ± 9.63	34.93 ± 11.75	33.47 ± 10.24	time since surgery – p < 0.0001
% EWL 6 months after surgery	44.59 ± 13.52	49.95 ± 13.75	49.96 ± 11.49	49.36 ± 13.26	time since surgery – p < 0.0001
% EBMIL 3 months after surgery	34.41 ± 11.24	36.88 ± 12.19	39.41 ± 12.67	37 ± 12.14	time since surgery – p < 0.0001
% EBMIL 6 months after surgery	53.59 ± 18.30	51.90 ± 15.88	54.0 ± 13.86	55 ± 15.60	time since surgery – p < 0.0001

hypertension (35%), type 2 diabetes (52%), and hyperlipidemia (15%). Preoperative eradication was performed in 5% of patients due to the presence of *Helicobacter pylori*. Glucose, insulin, HbA1_C, alanine and aspartate aminotransferase, bilirubin, total and fraction cholesterol, creatinine, urea, uric acid and CRP levels, as well as blood count and blood pressure values, were assessed prior to surgery and during follow-up visits 3 and 6 months after the procedures. BMI was assessed, and the percentage of excess weight lost (%EWL) was calculated using the following formula: %EWL = (initial weight – current weight)/(initial weight – ideal body weight) × 100. Excess BMI loss (%EBMIL) was calculated with the following formula: %EBMIL=100-[(current BMI-25/baseline BMI-25) ×100].

Inclusion criteria for the surgery were age > 18 years, BMI > 35, at least 1 comorbidity (e.g. arterial hypertension, diabetes) and at least 1 conservative therapy attempt in the patient's history. Exclusion criteria were mental disorders, alcohol dependence, injury, surgery or hospitalization within the last month, cancer and/or genetic diseases.

Before surgery, all the patients received a written information package on lifestyle and eating habit changes required after bariatric surgery. The package was taken home by each patient to be used in the future. The Bioethics Committee of the Medical University of Bialystok approved the study protocol.

Blood specimen collection

Blood specimens (10 mL) were collected after 8 to 12 h of overnight fasting. The specimens were collected from the forearm area by qualified medical personnel and were immediately transported to the analytical laboratory, where they were analyzed.

Surgical procedures

Laparoscopic adjustable gastric banding (LAGB) was performed by placing a silicone band around the upper part of the stomach. The diameter of the band was controlled by a liquid feed through a port implanted under the skin above the left costal arch and connected by a drain with the band. The band divided the stomach into 2 parts: an upper part, with a volume of about 25–40 mL, and a much larger bottom part.

Sleeve gastrectomy (SG) involved a total laparoscopic vertical resection of the stomach from the greater curvature.

The Roux-en-Y gastric bypass (RYGB) consisted of 3 stages: gastric reduction, gastroenterostomy, and an intestinal anastomosis of the enzymatic loop with the alimentary loop, all procedures performed laparoscopically.

Patients undergoing LAGB were discharged after 2 days; those undergoing SG were discharged after 4 or

5 days; and those who underwent RYGB were released after 6 or 8 days.

Statistical analysis

The χ^2 test was used to assess correlations between qualitative independent variables. Normal distribution was verified using the Lilliefors test (an adaptation of the Kolmogorov-Smirnov test) and the Shapiro-Wilk test. To compare ordinal variables and quantitative variables with non-normal distribution, the nonparametric Mann-Whitney test was used in cases of 2 groups; in cases of more than 2 groups, the nonparametric ANOVA Krus-kal-Wallis test with post-hoc analysis of multiple comparisons of mean ranks for all samples. To compare dependent variables, the Wilcoxon matched-pairs test was used in cases of 2 variables, and the Friedman ANOVA test in cases of many variables.

The results were statistically significant at p < 0.05. The statistical analysis was performed using STATISTICA v. 10.0 software (StatSoft, Tulsa, USA) and SPSS Statistics 21.0 (IBM Corp., Armonk, USA).

Results

Reductions in body weight

Most of the patients in the study group underwent SG (69.07%); 11.34% underwent LAGB, and 19.59% RYGB. The weight loss outcomes were assessed 3 and 6 months after surgery. The study group as a whole was assessed; outcomes in the LAGB, SG, RYGB groups and among the female/male participants were compared. Highly significant BMI differences (p < 0.001) were observed in the subsequent tests performed after surgery. Consistent, significant decreases in BMI were observed 3 months (39.31 ± 4.70) and 6 months (35.74 ± 4.52) after surgery. The largest BMI reduction at the 6-month follow up assessment was noted in the patients who had SG (12.29%), and the smallest BMI reduction was observed in those who had LAGB (9.02%). SG patients had a mean body weight loss of 24.17 kg and 35 kg after 3 and 6 months, respectively. A mean body weight loss of 18.5 kg after 3 months and 38 kg after 6 months was observed in RYGB patients. LAGB resulted in a body weight loss of 17.54 kg after 3 months and 28 kg after 6 months.

The time since surgery had significant (p < 0.001) effects on both %EWL and %EBMIL. The study considered a loss of at least 50% EWL in a year as a surgery-efficacy criterion, and this was achieved after 6 months in 44.59% of the LABG patients, 49.95% of the SG patients and 49.96% of the RYGB patients. The study considered a loss of less than 25% EWL as a surgery-failure criterion; there were no such cases in the study group. The results are presented in Table 1.

Table 2. Parameters of diabetes control in the study group

Parameters	Before surgery, med. ± SD	3 months after surgery, med. ± SD	6 months after surgery, med. ± SD	p-value
Glucose [mg/dL]	120.91 ± 38.88	103.66 ± 22.62	98.29 ± 12.22	< 0.001
Insulin [mU/L]	13.69 ± 5.61	13.08 ± 4.66	11.40 ± 3.07	ns
HbA1c %	6.98 ± 0.68	6.87 ± 0.52	6.65 ± 0.37	< 0.001
HOMA IR	4.84 ± 2.59	3.70 ± 1.73	2.87 ± 0.80	< 0.001
QUICKI	0.22 ± 0.02	0.23 ± 0.02	0.24 ± 0.01	< 0.001

Table 3. Glucose levels in the females and males in the study group

Glucos	se levels	Females	Males	p-value
Before surgery	Glucose [mg/dL]	112.07 ± 27.69	141.43 ± 53.81	0.009
3 months after surgery	Glucose [mg/dL]	96.17 ± 9.83	114.89 ± 34.73	0.008
6 months after surgery	Glucose [mg/dL]	95.75 ± 10.98	104.11 ± 13.52	0.002

Diabetes

In the study population, 51 patients were receiving treatment for type 2 diabetes, with a mean diabetes duration of 2.0 to 12.5 years. LAGB was performed on one of these patients, SG on 38 and RYGB on 12. Blood glucose levels of < 1 00 [mg/dL] and HbA1c levels < 6.5% were considered normal, in accordance with the National Institutes of Health guidelines.¹⁴ Highly significant differences (p < 0.001) were observed in blood glucose levels in subsequent tests. The mean preoperative glucose levels (120.55 \pm 39.19 mg/dL) were higher than the mean glucose levels 3 (101.58 ± 21.92 mg/dL) and 6 months $(98.16 \pm 12.30 \text{ mg/dL})$ after surgery. The patients' mean insulin levels decreased from 13.69 \pm 5.61 mU/L before surgery to 11.40 ± 3.07 mU/L 6 months after. The mean preoperative HbA1c was 6.98 \pm 0.68, and it significantly decreased (p < 0.001) after surgery, to 6.87 \pm 0.52 after 3 months and 6.65 \pm 0.37 after 6 months. Insulin resistance (IR) assessment was performed using homeostasis model assessment (HOMA) and quantitative insulin sensitivity check index (QUICKI), calculated based on the basis of serum glucose and insulin levels.¹⁵ A significant decrease (p < 0.001) in HOMA IR, which was 4.84 ± 2.59 prior to surgery and 2.87 ± 0.80 6 months after. The QUICKI index stabilized at 0.24 ± 0.01 6 months after surgery (Table 2).

The levels of different laboratory findings in men and women were analyzed. Reduced insulin and HbA1c levels, as well as changes in HOMA IR and QUICKI, were found in both groups, but the differences were not statistically significant. Glucose levels were found to be sig-

nificantly higher in men than in women, both prior to surgery as well as 3 and 6 months (p < 0.002) after. The data are presented in Table 3.

Hypertension

The study population included 23 patients diagnosed with and being pharmacologically treated for hypertension. Hypertension was defined as mean systolic blood pressure greater than 139 mm Hg and/or diastolic blood pressure higher than 89 mm Hg. The classifications of hypertension proposed in the 2003 ESH/ESC Guidelines were used for the group of patients included in the 6-month blood pressure follow-up. 16 The time elapsed since surgery was found to have significant effects (p < 0.001) effects on mean systolic and diastolic pressure. The mean preoperative systolic blood pressure was 140; 3 months after surgery it was 137, and 6 months after surgery it was 129. Mean diastolic blood pressure in the perioperative period was 89; it was 86 3

Fig. 1. Mean blood pressure levels in the study group before and after bariatric surgery

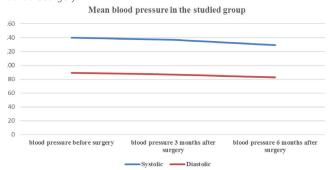


Table 4. Dyslipidemia assessment in the study group

Parameters	Before surgery	3 months after surgery	6 months after surgery	p-value
Total cholesterol [mg/dL]	207.35 ± 33.64	194.11 ± 37.60	194.92 ± 33.87	< 0.001
HDL [mg/dL]	50.09 ± 5.74	52.48 ± 4.92	55.66 ± 4.44	< 0.001
LDL [mg/dL]	171.86 ± 17.75	169.06 ± 6.58	165.41 ± 4.66	< 0.001
Triglycerides [mg/dL]	175.00 ± 26.65	161.24 ± 11.72	101.24 ± 13.68	< 0.001
QUICKI	0.22 ± 0.02	0.23 ± 0.02	0.24 ± 0.01	< 0.001

Table 5. Hepatic parameters in the study group

Hepatic parameters	Before surgery	3 months after surgery	6 months after surgery	p-value
AST [UI/L]	26.01 ± 11.37	22.28 ± 10.14	21.81 ± 8.65	0.002
ALT [UI/L]	34.11 ± 18.59	25.89 ± 16.81	23.30 ± 11.41	0.001
Bilirubin	0.92 ± 3.46	0.60 ± 0.30	0.58 ± 0.27	ns

months after surgery, and $82\,6$ months after surgery (Fig. 1). The surgery type had no significant effect on changes in blood pressure.

Dyslipidemia

The basic assessment of patients' lipid profiles involved an assay of total cholesterol, LDL and HDL cholesterol, as well as triglyceride levels. Statistically significant differences (p < 0.001) in total cholesterol levels were noted. The mean preoperative levels (207.35 ± 33.60 mg/dL) were significantly higher than the findings at the 6-month follow-up. A statistically significant correlation (p < 0.001) was found between time and the change in the fractions of HDL and LDL cholesterol. Mean HDL was 50.09 ± 5.74 mg/dL prior to surgery, 52.48 ± 4.92 mg/dL 3 months after surgery, and 55.66 ± 4.44 mg/dL after 6 months. Mean LDL was 175.00 ± 26.65 mg/dL prior to surgery, and it decreased significantly (p < 0.001) to 165.41 ± 4.66 mg/dL 6 months later. Mean triglyceride levels of 175.00 ± 26.65 decreased to 161.24 ± 11.72 3 months after surgery, and to 101.24 ± 13.68 after 6 months (p < 0.001) (Table 4).

Hepatic parameters

The 2 hepatic enzymes assessed – i.e. aspartate aminotransferase (AST) and alanine aminotransferase (ALT) – showed significant differences in the subsequent follow-ups. The mean preoperative AST level was 34.11 \pm 18.78 Ul/L; it decreased to 22.18 \pm 10.21 Ul/L after 3 months, and to 21.80 \pm 8.78 Ul/L after 6 months (p = 0.002). Similarly, the mean preoperative ALT level was 34.11 \pm 18.78 Ul/L;

it decreased to 34.11 \pm 18.78 Ul/L after 3 months, and to 23.34 \pm 11.53 Ul/L after 6 months (p = 0.001). The analysis of bilirubin levels showed a decrease at the 6-month follow-up, but the difference was not statistically significant (Table 5).

Renal parameters

No differences were found between the mean preoperative level of uric acid (5.43 \pm 1.28 mg/dL) and the level 3 months after surgery. However, a significant decrease to 5.08 \pm 1.27 mg/dL was noted after 6 months. The analyses of creatinine and urea showed no statistically significant differences (Table 6).

Blood counts

Complete blood counts showed a highly significant difference (p < 0.001) in WBC levels. The mean preoperative WBC level did not differ from the level observed 3 months after surgery, but a significant decrease from 7.45 ± 2.17 to 6.57 ± 1.47 was noted at the 6-month follow-up. Other blood count parameters (RBC, hemoglobin and platelets), remained unchanged (Table 7).

C-Reactive protein (CRP)

The mean preoperative CRP level in the study group was 9.15 ± 9.92 mg/L, which increased to a mean of 9.29 ± 11.89 mg/L 3 months after surgery, then decreased to a mean value of 8.58 ± 12.36 mg/L 6 months after surgery. These changes were not statistically significant.

Table 6. Renal parameters in the study group

Renal parameters	Before surgery	3 months after surgery	6 months after surgery	p-value
Creatinine [mg/dL]	0.84 ± 0.36	0.80 ± 0.15	0.81 ± 0.31	ns
Urea [mg/dL]	31.06 ± 9.42	31.37 ± 13.8	32.08 ± 12.1	ns
Uric acid [mg/dL]	5.74 ± 3.31	5.47 ± 1.47	5.34 ± 2.79	ns

Table 7. Blood count assessment in the study group

Parameters	Before surgery	3 months after surgery	6 months after surgery	p-value
WBC	7.48 ± 2.17	7.27 ± 1.42	6.56 ± 1.46	0.001
RBC	4.80 ± 0.45	4.79 ± 0.37	4.85 ± 0.38	ns
HGB	13.63 ± 1.20	14.77 ± 12.10	13.57 ± 1.00	ns
PLT	275.96 ± 62.22	278.18 ± 47.52	267.04 ± 53.83	ns

Discussion

Currently, obesity is a major public health concern due to the number of correlations with chronic diseases. Although obesity affects a large proportion of the entire population, an increase in the incidence of obesity has been observed in rural areas. This issue has been highlighted by research conducted in Poland, the US, India, and China. It could be the result of rural residents adopting unhealthy habits that previously were present primarily in urban areas (e.g. frequent TV watching, low physical activity, high-calorie meals). The number of women with obesity is somewhat higher than the number of obese men, which was confirmed by the present study (29% men, 71% women).

A study by Gajewska et al. shows the 2008 rates of hospitalization in Poland that were due to obesity, and took the place of residence into consideration. The study found that treatment was undertaken more frequently by urban than by rural residents (19.9 vs 14.4 per 100,000). Bariatric procedures represent one of the options in the treatment of obesity. These procedures require a skilled surgical team, the involvement of many specialists, and should be performed in referral centers. Patients need to be aware that surgery does not mean treatment is completed; they must understand that they are expected to cooperate in terms of lifestyle and diet changes, as well as regular follow-up visits. Socio-economic factors may prevent rural residents from maintaining long-term bariatric monitoring.

The laparoscopic technique is presently used for the majority of bariatric procedures. Restrictive LAGB and LSG procedures do not result in significant malabsorption and show high efficacy for weight loss.^{20–22}

All 3 types of procedures used in the present study were performed laparoscopically by the same surgical team at the Medical University of Bialystok Clinical Hospital.

LAGB is a reversible method, and does not require nutritional supplementation in the postoperative period. The efficacy of LAGB and LSG was compared among US patients with severe obesity by Varela, who concluded that although both surgical techniques were safe and effective, LSG ensures greater weight loss over a 2-year follow-up period.²³ The RYGB technique combines limited gastric capacity with reduced absorption, and therefore has a high efficacy. This type of surgery leads to anatomical alterations, frequently irreversible. Several studies have assessed the use of RYGB and compared its outcomes with those of other bariatric procedures.^{24–27} RYGB was shown to very effectively reduce body weight; however, a higher incidence of complications associated with anastomotic leakage, pulmonary embolism, deep vein thrombosis, as well as frequent wound infections and postoperative hernia was observed. In the present study, the patients were qualified for the procedures on the basis of the current guidelines and a number of tests developed by a specialist panel, as well as consultations and each patient's personal commitment.²⁸ The possibilities for continuing follow-up visits at the referral center were evaluated in detail, taking into account the oftendistant places of residence of those in the study group.

Comparative studies conducted in a number of bariatric centers indicate that SG and RYGB result in greater weight reduction than LAGB.^{24–27} The present study obtained similar results. The largest BMI reduction at the 6-month follow up was observed for SG (12.29%), and the smallest BMI reduction was observed for LAGB (9.02%). The patients who qualified for SG had a mean preopera-

tive BMI of 48.55 ± 5.52 , which decreased to 36.26 ± 4.78 6 months after surgery. The mean BMI in the RYGB patients was 44.95 ± 4.21 prior to surgery and 34.71 ± 3.92 after 6 months; the mean BMI in the LAGB patients was 43.41 ± 3.40 prior to surgery and 34.3 ± 3.49 after 6 months. These results indicate a correlation between the time elapsed since the surgery and the reduction in body weight. Other studies have shown similar results after a longer follow-up period. $^{24-28}$

Earlier studies have shown a marked improvement and normalization of parameters assessing diabetes control following bariatric treatment. 29,30 The present study assessed only SG and RYGB in this respect, because LAGB was used in only 1 patient with type 2 diabetes. A statistically significant reduction (p < 0.001) in insulin and HbA1c levels was noted at the 6-month follow-up. Statistically significant reductions (p < 0.001) in HOMA IR (from 4.84 ± 2.59 to 2.87 ± 0.80) and altered QUICKI index (from 0.22 ± 0.02 to 0.24 ± 0.01) were also observed. Type 2 diabetes remission was observed in patients after both SG and RYGB. The effect of lower caloric intake following surgery was considered one of the mechanisms involved in the rapid decrease in insulin resistance. Limited food intake can result in plasma glucose and insulin normalization even prior to weight loss. The so-called surgical impact, i.e. postoperative stress inducing the release of catecholamines, which may inhibit insulin secretion, could also play a role.

In the same teaching hospital where the present study was conducted, Hady et al. assessed the effects of LAGB on concomitant type 2 diabetes in 100 patients, based on a 6-month follow-up period.³¹ Parameters such as insulin and glucose levels, as well as HOMA IR were assessed. LAGB was shown to improve patient health status and normalize type 2 diabetic parameters.

In relation to cardiovascular risk, the present study showed a significant increase (p < 0.001) in HDL cholesterol levels, from 50.09 ± 5.74 mg/dL prior to surgery to 55.66 ± 4.44 mg/dL 6 months after the procedure. Furthermore, significant decreases (p < 0.001) were noted in total and LDL cholesterol, as well as triglyceride levels. Similar results were obtained by Hady et al. for LAGB after a 6-month follow-up period, with a significant improvement in the lipid profile, decreased total and LDL cholesterol, as well as lowered triglyceride levels.³¹ A 3-month observation conducted by Waldmann et al. following SG procedures showed an approximate 20% reduction in TG and slightly decreased HDL cholesterol levels.32 A review of 26 studies assessing the outcomes of bariatric procedures over a 2-year follow-up period performed by Al Khalifa et al. showed resolution or improvement of hyperlipidemia in 83.5% of the patients.³³ Benaiges et al. found less improvement in hyperlipidemia in SG patients (75%) than in patients who had undergone RYGB (100%).³⁴ According to those authors, the reduced LDL cholesterol levels observed following RYGB may be associated with the malabsorption induced by this surgical technique. A large amount of data support this hypothesis. 2

There are studies that support the positive effects of bariatric surgery on non-alcoholic hepatic steatosis through bodyweight reduction and metabolic syndrome improvement. The present analysis shows a significant improvement in parameters representing risk factors for this disease. Statistically significant reductions in hepatic enzymes were noted, regardless of surgery type: ALT (from 34.11 ± 18.59 to 23.30 ± 11.41 ; p = 0.002), and AST (from 26.01 ± 11.37 to 21.81 ± 8.65 ; p = 0.001).

Some studies indicate obesity and RYGB as risk factors for urolithiasis and other urinary conditions. Maalouf, et al. confirmed an increased tendency to urolithiasis following RYGB.³⁶ In the present study, a decrease was found in uric acid levels during the 6-month follow-up (from 5.74 ± 3.31 to 5.34 ± 2.79).

Basic blood counts confirmed decreased WBC levels at the 6-month follow-up (7.48 \pm 2.17 vs. 6.56 \pm 1.46), which was statistically significant (p < 0.001). No statistically significant changes in CRP levels were noted during the 6-month follow-up period, although reductions were observed. The short (6-month) follow-up period was a limitation of the present study.

Conclusions

The present study confirms the positive effect of bariatric procedures such as LAGB, SG and RYGB on body-weight reduction over a 6-month follow-up period. Improvements were also found in the general health status of the patients, as well as normalization of metabolic parameters (glucose, cholesterol, triglycerides, hepatic enzymes).

Although LAGB, SG, and RYGB are safe procedures with similar weightloss outcomes, LAGB or SG may prove to be better options in rural patient populations due to the complexity of the RYGB procedure and potential nutrition-related complications following RYGB. Surgical techniques should be individually chosen for each patient; the distance of the patient's place of residence from the treatment facility and the patient's difficulties in participating in an outpatient monitoring program following bariatric surgery should be considered when qualifying patients for bariatric procedures.

References

- World Health Organization. Obesity and Overweight. 2011. http:// www.who.int/mediacentre/factsheets/fs311/en/print.html, 2011.
- Buchwald H, Avidor Y, Braunwald E, et al. Bariatric surgery: A systematic review and meta-analysis. JAMA. 2004;292(14): 1724–1737.
- Babińska Z, Trzeciak BG, Bandosz P, etal. Rozpowszechnienie nadwagi i otyłości w populacji wiejskiej- Program "Kiełpino". Prim Care Rev. 2006:8:569–571.
- GUS. Ludność. Stan i struktura w przekroju terytorialnym. Stan w dniu 30.06.2013 r.

- Sullivan PW, Ghushchyan VH, Ben-Joseph R. The impact of obesity on diabetes, hyperlipidemia and hypertension in the United States. Qual Life Res. 2008;17(8):1063–1671. doi: 10.1007/s11136-008-9385-7.
- Nguyen NT, Magno CP, Lane KT, et al. Association of hypertension, diabetes, dyslipidemia, and metabolic syndrome with obesity: Findings from the National Health and Nutrition Examination Survey, 1999 to 2004. J Am Coll Surg. 2008;207(6):928–934. doi: 10.1016/j.jamcollsurg.2008.08.022.
- Gloy VL, Briel M, Bhatt DL, et.al. Bariatric surgery versus non-surgical treatment for obesity: a systematic review and meta-analysis of randomized controlled trials. *BMI*. 2013;347:f5934. doi: 10.1136/bmi.f5934
- Biter LU, Gadiot RP, Grotenhius BA, et al. The Sleeve Bypass Trial:
 A multicenter randomized controlled trial comparing the long-term outcome of laparoscopic sleeve gastrectomy and gastric bypass for morbid obesity in terms of excess BMI loss percentage and quality of life. BMC Obes. 2015;2:28.
- Toolabi K, Golzarand M, Farid R. Laparoscopic adjustable gastric banding: Efficacy and consequences over a 13-year period. *Am J Surg*. 2015 doi: 10.1016/j.amjsurg.2015.05.021.
- Schauer PR, Kashyap SR, Wolski K, et al. Bariatric surgery versus intensive medical therapy in obese patients with diabetes. N Engl J Med. 2012,26;366(17):1567–1576. doi: 10.1056/NEJMoa1200225.
- Mingrone G, Panunzi S, De Gaetano A, et al. Bariatric surgery versus conventional medical therapy for type 2 diabetes. N Engl J Med. 2012;366:1577–1585.
- 12. Raffaelli M, Guidone C, Callari C, et al. Effect of gastric bypass versus diet on cardiovascular risk factors. *Ann Surg.* 2014;259(4):694–699.
- Befort CA, Nazir N, Perri MG. Prevalence of obesity among adults from rural and urban areas of the United States: Findings From NHANES (2005–2008). J Rural Health 2012;28(4):392-397. doi:10.1111/ j.1748-0361.2012.00411.x.
- Zalecenia kliniczne dotyczące postępowania u chorych na cukrzycę 2014. Stanowisko Polskiego Towarzystwa Diabetologicznego. Clinical Diabetology. 2014; 3, supl. A.
- Wallace TM, Levy JC, Matthews DR. Use and abuse of HOMA modeling. *Diabetes Care*. 2004;27(6):1487–1495.
- Tykarski A, Grodzicki T. 2007 ESH/ESC Guidelines for the Management of Arterial Hypertension-what new? Attempt of commentary on changes and their validity. Arterial Hypertension. 2007;11(4):261–303.
- Chopra SM, Misra A, Gulati S, et al. Overweight, obesity and related non-communicable diseases in Asian Indian girls and women. Eur J Clin Nutr. 2013;67(7):688–696.
- Hu J, Si Y, Zhou D, et al. Prevalence and treatment gap of active convulsive epilepsy: A large community-based survey in rural West China. Seizure. 2014;17. doi: 10.1016/j.seizure.2014.01.007.
- Gajewska M, Goryński P, Wysocki MJ. Obesity and type 2 diabetes as main causes of hospitalization in Polish hospitals in 2008. Probl Hig Epidemiol. 2011;92(1):132–136.
- Abbatini F, Rizzello M, Casella G, et.al. Long-term effects of laparoscopic sleeve gastrectomy, gastric bypass, and adjustable gastric banding on type 2 diabetes. Surg Endosc. 2010;24(5):1005–1010. doi: 10.1007/s00464-009-0715-9.
- Silecchia G, Boru C, Pecchia A, et al. Effectiveness of laparoscopic sleeve gastrectomy (first stage of biliopancreatic diversion with duodenal switch) on co-morbidities in super-obese high-risk patients. Obes Sur. 2006;16(9):1138–1144.

- Helmio M, Victorzon M, Ovasaka J. et al. Sleevepass: a randomized prospective multicenter study comparing laparoscopic sleeve gastrectomy and gastric bypass in the treatment of morbid obesity: preliminary results. Surg Endosc. 2012;26(9):2521–2526. doi: 10.1007/ s00464-012-2225-4.
- Varel JE. Laparoscopic Sleeve Gastrectomy versus Laparoscopic Adjustable Gastric Banding for the treatment severe obesity in high risk patients. *JSLS*. 2011;15(4):486–491. doi:10.4293/108680811X13176.
- Nguyen NQ, Game P, Bessel J, et al. Outcomes of Roux-en-Y gastric bypass and laparoscopic adjustable gastric banding. World J Gastroenterol. 2013;19(36):6035–6043.
- Li JF, Lai DD, Lin ZH, et al. Comparison of the long-term results of Roux-en-Y gastric bypass and Sleeve Gastrectomy for morbid obesity: A systematic review and meta-analysis of randomized and nonrandomized trials. Surg Laparosc Endosc Percutan Tech. 2014;24(1):1–11.
- Paluszkiewicz R, Kalinowski P, Wróblewski T, et al. Prospective randomized clinical trial of laparoscopic sleeve gastrectomy versus open Roux-en-Y gastric bypass for the management of patients with morbid obesity. Videosurgery and other Miniinvasive Techniques. 2012;7(4):225–232. doi:10.5114/wiitm.2012.32384.
- Tice JA, Karliner L, Walsh J, et al. Gastric Banding or Bypass? A systematic review comparing the two most popular bariatric procedures. Am J Med. 2008;121(10):885–893.
- Fred M, Hainer W, Basdevant A, et al. Interdisciplinary European guidelines on surgery of severe obesity. Obes Surg. 2007;17(2): 260–270.
- 29. Singh AK, Singh R, Kota SK. Bariatric surgery and diabetes remission: Who would have thought it? *Indian J Endocrinol Metab*. 2015:19(5):563–576.
- Musella M, Apers J, Rheinwalt K, et al. Efficacy of bariatric surgery in type 2 diabetes mellitus remission: The role of mini gastric bypass/ one anastomosis gastric bypass and sleeve gastrectomy at 1 year of follow-up. A European survey. Obes Surg. 2015; DOI 10.1007/ s11695-015-1865-6.
- 31. Hady HR, Dadan J, Gołaszewski P. 100 obese patients after laparoscopic adjustable gastric banding-the influence on BMI, ghrelin and insulin concentration, parameters of lipid balance and co-morbidities. *Adv Med Sci.* 2012;57(1):58–64.
- 32. Waldmann E, Hüttl TP, Göke B, et al. Effect of sleeve gastrectomy on postprandial lipoprotein metabolism in morbidly obese patients. *Lipids in Health and Disease*. 2013;12:82.
- 33. Al Khalifa K, Al Ansari A, Alsayed AR, et.al. The impact of Sleeve gastrectomy on hyperlipidemia: A systematic review. *Journal of Obesity*. 2013; Article ID 643530, 7 pages.
- 34. Benaiges D, Flores-Le-Roux JA, Pedro-Botet J, et al. Impact of restrictive (Sleeve Gastrectomy) vs hybrid bariatric surgery (Roux-en-Y Gastric Bypass) on lipid profile. *Obes Surg.* 2012;22(8): 1268–1275. doi: 10.1007/s11695-012-0662-8.
- Klein S, Mittendorfer B, Eagon JC, et al. Gastric Bypass Surgery improves metabolic and Hepatic Abnormalities associated with Nonalcoholic Fatty Liver Disease. *Gastroenterology* 2006;130(6): 1564–1572.
- Maalouf NM, Tondapu P, Guth ES, et al. Hypocitaturia and hyperoxaluria after Roux-en-Y Gastric Bypass Surgery. J Urol. 2010;183(3):1026–1030. doi: 10.1016/j.juro.2009.11.022.