THE EFFICACY OF SELECTED BARIATRIC SURGERY METHODS ON LIPID AND GLUCOSE METABOLISM: A RETROSPECTIVE 12-MONTH STUDY

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SUMMARY

Objective: Approximately 25% of the Czech population is currently obese. Obesity rates are expected to increase in the future. Obesity not only raises the risk of health complications for individuals, but increasing rates also represent a significant and steadily growing economic burden for healthcare systems and society as a whole. The aim of this study was to evaluate the therapeutic efficacy of three methods of bariatric surgery: laparoscopic greater curve plication (LGCP), laparoscopic sleeve gastrectomy (LSG), and Roux-en-Y gastric bypass (RYBG) in patients with type 2 diabetes mellitus (DM). This study examined the influence of bariatric surgery on body weight and BMI, changes in serum glucose and markers of lipid metabolism.

Methods: This study evaluated outcomes in 74 patients with type 2 DM who underwent LGCP, LSG or RYGB. Patient selection followed guidelines of the International Federation for the Surgery of Obesity, i.e. BMI ≥ 40 kg/m^2 or BMI ≥ 35 kg/m^2 with associated comorbidities or BMI < 35 kg/m^2. For each of the procedures, the hypotheses were tested with the Bonferroni method.

Results: Statistically significant weight loss, 20.2 ± 9.3 kg on average, occurred by 12 months after surgery, with maximum weight reduction of 38 kg. Over the 12-month period, average fasting glycaemia decreased by 2.58 mmol/L after LGCP, by 2.01 mmol/L after LSG, and by 4.64 mmol/L after RYGB. Triacylglycerol (TGC) values decreased significantly with all procedures. The mean decrease was 1.35 mmol/L after LGCP and 1.06 mmol/L after LSG. The greatest TGC concentration decrease, 1.92 mmol/L, occurred after RYGB. Average concentrations decreased below 1.7 mmol/L. There was a statistically significant difference in body weight and BMI reduction between LGCP and LSG groups, as well as between LGCP and RYGB groups. A significant difference in the glucose decrease was observed between the LSG and RYGB groups, which can be explained by the fact that glycaemia and HbA1c levels were different between these groups prior to surgery.

Conclusions: The best results from the carbohydrate metabolism point reached the malabsorption method RYGB. However, the other two restrictive methods also achieved very good results. In particular, the LGCP method has not only the effect on weight reduction but also on metabolic functions and consequently points to potential healthcare expenditure savings.

Key words: bariatric surgery, case study, Czech Republic, LGCP, LSG, RYGB outcomes

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INTRODUCTION

Over the past 20 years, the prevalence of obesity has increased almost twofold in most European countries, including the Czech Republic. Obesity currently affects 10 to 25% of men and 10 to 30% of women in Europe. The situation is even graver in the US, where obesity affects 34% of the adult population; 5% of the adult population in the US suffers from class III morbid obesity (1). In countries of the Central and Eastern Europe, including the Czech Republic, the prevalence of obesity stands as a forefront issue in all epidemiological studies. Results of the latest large epidemiological study, conducted in the Czech Republic, reveal 30% of the Czechs to be overweight and 25% as suffering from obesity. It is an alarming fact that, during the recent 6 years only, the number of obese subjects has increased by 5% in the total population of 10.3 million, what makes 425,000 people (2).

Recently, a series of epidemiologic studies has evidenced a close link between morbid obesity and type 2 diabetes mellitus (DM), hypertension, hyperlipidemia, obstructive sleep apnea, metabolic syndrome, and insulin resistance (3, 4). The scale of the problem is also confirmed by the fact that obesity, when exceeding 40 kg/m^2, shortens life span, on average by 20 years, while obesity consequences are more severe than the consequences of tobacco smoking or alcohol consumption (5).

The treatment of obese patients is a demanding and long-term undertaking, in which there are no "short cuts" or "quick fixes". Literature data clearly show that no weight loss after pharmacotherapy or dietotherapy remains effective in a long run (6, 7). Today, surgical treatment of higher obesity levels is undoubtedly the most effective procedure with the best outcomes in a long time perspective (8). Dramatic weight loss leads to improvement of associated comorbidities as well. The results of studies,

published in the recent decade, have demonstrated that weight reduction by 35–40%, following surgical intervention treatment of obesity, may be regarded permanent, as it is maintained for more than 5 years (9).

The purpose of this study was to evaluate the therapeutic efficacy of three bariatric surgery procedures, the laparoscopic greater curve plication (LGCP), laparoscopic sleeve gastrectomy (LSG), and Roux-en-Y gastric bypass (RYGB) methods, in obese patients with type 2 DM. The following variables were assessed 12 months after surgery versus preoperatively:

- Changes in body weight and BMI;
- Changes in serum glucose and lipid metabolism markers.

MATERIALS AND METHODS

Design

The study in patients following LSG, RYGB and LGCP was carried out between March 2012 and February 2016 at the Obesitology Research Centre of the University of Ostrava, Czech Republic, and at the Bariatric Surgery Centre, Vítkovice Hospital, Czech Republic. Inclusion criteria included BMI $\geq$40 kg/m^2 or $\geq$35 kg/m^2 with comorbidities or BMI < 35 kg/m^2, and age 18–65 years, as per the International Federation for the Surgery of Obesity (IFSO) criteria (10). Exclusion criteria included BMI > 50 kg/m^2, any prior abdominal surgery, diagnoses for gastric or duodenal ulcers, thyroid gland disease, and gastrointestinal disease.

For each of the procedures, the following hypotheses were tested:

H1: There will be a total body weight and BMI reduction 12 months after surgery without a significant difference among individual procedure groups.

H2: Serum glucose and lipid metabolism markers will change by 12 months after surgery without a significant difference among individual procedure groups.

Statistical Analysis

The hypotheses were tested with the Bonferroni method (11). Normality of data distribution was assessed on the basis of skewness and kurtosis. Data with normal distribution were tested with the paired t-test, and data without normal distribution with the paired Wilcoxon test. The statistical tests were evaluated at a 5 % level of significance. MS Excel was used for processing.

RESULTS

The research set included 74 patients, 23 men and 51 women. Patient age ranged from 33 to 65 years, with a mean of 52.7 ± 9.1 years. The mean age of the men was 54.2 years; that of the women was 52.0 years. Most patients who undergo bariatric procedures have obesity of a higher class. There were no patients under 30 years of age in the study, which corresponds with the fact that occurrence of type 2 DM in the population increases with age. Thirty-nine percent of the patients underwent LGCP, 38% underwent RYGB, and 23% underwent LSG.

Changes in Body Weight and BMI

The mean body weight of patients who underwent LGCP surgery was 118.7 ± 15.2 kg (range: 83–153 kg); the corresponding BMI was 41.7 ± 4.1 kg/m^2 (range: 31.0–49.0 kg/m^2). Statistically significant weight loss, 20.2 ± 9.3 kg on average, occurred by 12 months after surgery, with maximum weight reduction of 38 kg. Mean total weight loss in percent (%TWL) was 18%. Mean BMI after surgery was 33.8 kg/m^2 (Table 1).

Mean patient weight before LSG was 127.3 ± 20.2 kg (range: 100–177 kg) and mean BMI was 42.9 ± 5.7 kg/m^2 (range: 33.0–56.0 kg/m^2). Follow-up 12 months after surgery revealed an average weight loss of 31.3 ± 12.2 kg (25 %TWL), with maximum reduction of 59 kg. The average BMI reduction was 10.5 ± 4.7 kg/m^2 (Table 1).

The average body weight of RYGB patients before surgery was 118.8 ± 19.9 kg (range: 85–168 kg). Mean BMI was 43.4 ± 6.5 kg/m^2 (range: 33.8–59.5 kg/m^2). Weight loss was similar to that of the LSG patients; however, the mean %TWL was 30%, with average weight after surgery of 84.4 ± 16.7 kg. BMI fell to 30.9 ± 4.6 kg/m^2.

Figure 1 compares BMI before surgery to BMI 1 year after surgery, according to bariatric procedure. The mean values for patients undergoing all procedures were above 40 kg/m^2, corresponding to Class III obesity. One year after surgery, the mean values had decreased to 30–35 kg/m^2, corresponding to class I obesity.

Serum Glucose and Lipid Metabolism Markers

Evaluation of individual laboratory parameters was based on the recommendations of the Czech Diabetes Society (12). Glycaemia $\leq$6.0 mmol/L and glycated haemoglobin (HbA1c)

Table 1. *Weight loss and BMI decrease according to bariatric procedure (N = 74)*

		RYGB			LSG			LGCP		
		n	Mean	SD	n	Mean	SD	n	Mean	SD
Before surgery	Weight (kg)	28	118.8	19.9	28	127.3	20.2	29	118.7	15.2
1 year after surgery		26	84.4	16.7	26	84.4	13.5	26	97.8	13.5
Weight loss		26	34.6	11.5	26	31.3	12.2	26	20.2	9.3
Before surgery	BMI (kg/m^2)	28	43.4	6.5	28	42.9	5.7	29	41.7	4.1
1 year after surgery		26	30.9	4.6	26	31.3	12.2	26	33.8	3.5
BMI reduction		26	13.9	4.4	26	10.5	4.7	26	7.4	3.1
Mean total weight loss	(%)	26	29.1	10.1	26	15.9	14.1	26	17.1	14.2

<4.5% (<4.8%, according to the International Federation of Clinical Chemistry) were considered a therapeutic success. Over the 12-month period, average fasting glycaemia decreased by 2.58 mmol/L after LGCP, by 2.01 mmol/L after LSG, and by 4.64 mmol/L after RYGB. As shown in Fig. 2, glycaemia decreased below 6 mmol/L with all procedures.

The changes were significant for all procedures. Mean HbA1c, which reflects fluctuations of blood glucose within the previous month, decreased significantly by 1.04% in the LGCP patients and by 1.8% in the LSG patients. The greatest mean HbA1c decrease, 2.97%, occurred in the RYGB group. HbA1c concentration decreased below 4.5% after all procedures. Comparisons of glucose metabolism parameters are presented in Figure 2.

Mean total cholesterol increased by 0.14 and 0.34 mmol/L for LGCP and LSG, respectively, but the difference was not statistically significant. In contrast, RYGB led to a statistically significant mean total cholesterol decrease of 0.85 mmol/L. RYGB likewise led to a statistically significant decrease in LDL cholesterol of 0.82 mmol/L. LGCP and LSG procedures caused only small changes without statistical significance. HDL cholesterol increased significantly with all surgical procedures. The greatest mean HDL increase (0.58 mmol/L) occurred with the LSG procedure. LGCP resulted in a mean HDL increase of 0.37 mmol/L, the smallest increase (0.23 mmol/L) was seen with RYGB.

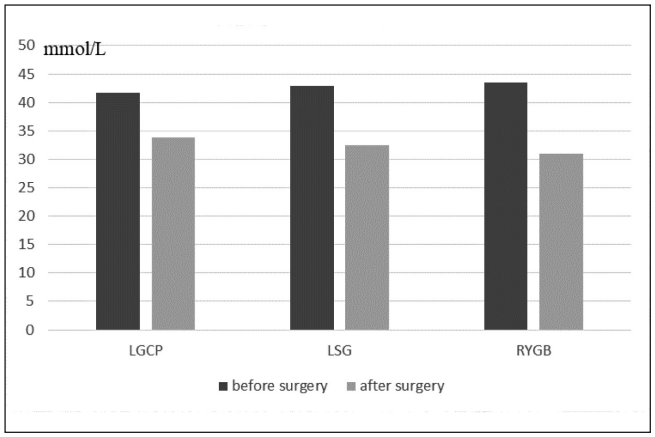

Fig. 1. *Comparison of mean BMI values before and 1 year after surgery.*

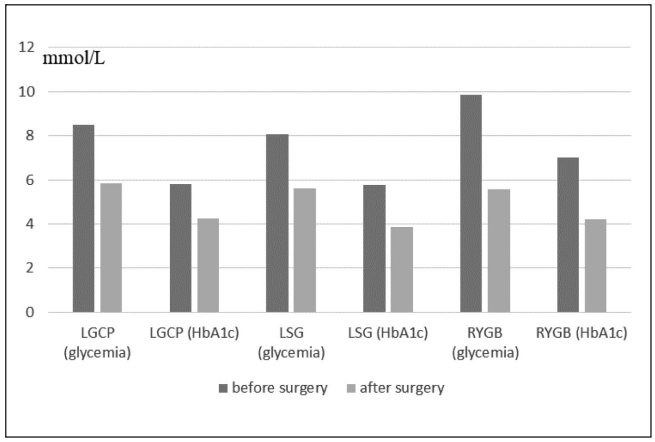

Fig. 2. *Comparison of mean glucose metabolism values before and 12 months after surgery.*

Triacylglycerol (TGC) values decreased significantly with all procedures. The mean decrease was 1.35 mmol/L after LGCP and 1.06 mmol/L after LSG. The greatest TGC concentration decrease, 1.92 mmol/L, occurred after RYGB. Average concentrations decreased below 1.7 mmol/L.

Based on the Bonferroni comparison, there was a statistically significant difference in blood glucose levels between the LSG and RYGB groups. Differences in blood glucose between LGCP and LSG groups, as well as between LGCP and RYGB groups, were not significant. (Table 2).

DISCUSSION

Bariatric procedures are, at present, the only effective solution for obesity in terms of yielding a sustainable long-term

Table 2. *Bonferroni comparison of procedures based on changes in laboratory parameters*

	LSG	LGCP
Comparison based on glycaemia		
LGCP	0.57	
p-value	NS	
RYGB (tested difference)	2.63	2.06
p-value	0.017	NS
Comparison based on glycated haemoglobin		
LGCP	–0.77	
p-value	NS	
RYGB (tested difference)	1.16	1.94
p-value	NS	0.001
Comparison based on total cholesterol		
LGCP	–0.20	
p-value	NS	
RYGB (tested difference)	1.19	0.99
p-value	0.007	0.026
Comparison based on HDL cholesterol		
LGCP	–0.22	
p-value	NS	
RYGB (tested difference)	0.35	0.14
p-value	0.035	NS
Comparison based on LDL cholesterol		
LGCP	–0.01	
p-value	NS	
RYGB (tested difference)	0.89	0.91
p-value	0.047	0.037
Comparison based on triacylglycerols		
LGCP	0.30	
p-value	NS	
RYGB (tested difference)	0.86	0.57
p-value	NS	NS

NS – not significant

body weight reduction and decrease in the incidence of obesity-associated comorbidities (13). LSG is one of several standard procedures, inclusive of RYGB. LSG is particularly popular due to its simplicity, safety, and high efficacy in resolving morbid obesity (14). Conversely, LGCP is a newer bariatric technique that warrants attention because of its results, although it is yet to be accepted by practitioners as a standard procedure. Although LGCP is categorized as a restrictive bariatric surgical procedure, some authors ascribe no metabolic component to this surgery (i.e. decreased ghrelin secretion, changes of serum lipids) (15). On the other hand, our data, together with recent studies, demonstrates LGCP's indisputable restrictive impact, together with an endocrine effect (16). Comparing the results achieved in patient cohorts having undergone either procedure provides important data with which to inform decision-making in terms of the appropriate course of action in resolving obesity in individual patients.

Obesity, jointly with the fat tissue share close to 50%, is among significant risk factors of cardiovascular and metabolic disorders. Health risks associated with obesity increase with growing volumes of intra-abdominal adipose tissue. From this perspective, there has been a high positive reduction in body weight and BMI, observed in our study. In terms of success, DeAquino (17) defines bariatric procedures as successful if patients demonstrate weight loss below 25% of their preoperative level, satisfactory, if they lose 25–30% of their preoperative weight, and very good if the weight loss is above 30% of its total preoperative value. Consequently, our results of weight reduction can be evaluated as successful and comparable with the results of similar studies of patients after bariatric procedures such us laparoscopic sleeve gastrectomy or laparoscopic gastric plication (18, 19).

The main obesity-related metabolic risk factors of the cardiovascular disease involve low serum HDL cholesterol levels with increased levels of triacyglycerols (TG) and LDL cholesterol levels.

During twelve months after the surgical intervention, significant changes in the lipid profile were reported, specifically an increase of HDL cholesterol and decreased of triacylglycerols (in all of the cohorts). On the other hand, no statistically significant changes were reported in total in LDL cholesterol levels. Similar results were obtained by Strain et al. (20). One year after LSG, they reported a significant increase of HDL cholesterol levels, while, similarly as in our study, LDL and total cholesterol remained unchanged.

Regarding the cardiovascular risks, the observed increased HDL cholesterol and decreased TG levels are fairly positive, prognostic factors. Similar results were also obtained by Vidal et al.(21) with a significant improvement of lipid profile following LSG (improved hypertriglyceridaemia in 80% of the group and increased HDL cholesterol in 50% of the group), including reduced risk for the metabolic syndrome. Apart from dyslipidaemia, the positive changes after LSG and RYGB include a therapeutic impact on other obesity-connected comorbidities; following the operation, more than 75% of patients demonstrated an improved control of diabetes mellitus within 3 years (22, 23).

Our follow-up data confirmed the statistically significant influence of LSG, RYGBP and LGCP on glucose homeostasis, confirming reduced blood glucose and the correction of HbA1c in agreement with previous data (24). The positive effect on glucose homeostasis can be attributed to a reduction of insulin resistance, increased insulin secretion, and improved tissue responses to insulin (25). Slater et al. (26) stated that positive effects on the glycaemic curve and remission in type 2 DM patients were evident before a pronounced body weight reduction. This leads us to suggest complex roles for the gastric hormones ghrelin and YY peptide in the regulation of pancreatic endocrine function and systemic insulin resistance. Post-operative diet is another factor that influences glucose homeostasis. These findings illustrate that, like LSG, RYGB including LGCP also has a metabolic effect, agreeing with a short-term study (13, 27) reporting that 96.9% of type 2 DM patients exhibited (at the least) some improvement of their preoperative diabetic status 6 months after LGCP, with pre- and postprandial improvement of insulin sensitivity (16, 28).

CONCLUSION

Bariatric surgery has a positive effect on the treatment of obesity. After twelve months there was a significant reduction in weight and BMI without a statistical difference between LSG and RYGB, but a significant decrease was recognized in LGCP patients. At the same time, there has been a change in lipid metabolism in patients. The increase in serum HDL cholesterol, which was more significant in LSG and LGCP, and a decrease in the concentration of triacylglycerols, which was the most significant in RYGB, is essential. In total cholesterol and LDL cholesterol, there was a significant decrease in RYGB alone.

Good restriction results were obtained following LGCP, which might be mediated via altered glucose metabolism and gastrointestinal hormones. Nevertheless, this method is less effective than LSG and RYGB, possibly due to its preservation of the entire stomach, including secretory regions. LGCP could however be useful (particularly) for patients who refuse malabsorption and metabolic procedures, or for those concerned with the irreversibility of LSG and RYGB.

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Conflict of Interests

None declared

Adherence to Ethical Standards

The study was approved by the Ethics Committee at the Faculty of Medicine, University of Ostrava in accordance with the ethical standards of the Helsinki Declaration of 1975, as amended in 2000. Informed consent was obtained from all participants included in the study. The study had a retrospective design (ClinicalTrials.gov registration: NCT02893891).

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