UNKNOWN FACTORS OF TYPE 2 DIABETES REMISSION AFTER METABOLIC SURGERY

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Type 1 and type 2 diabetes are characterized by progressive β-cell failure. Bariatric surgery leads to near complete resolution of type 2 diabetes (T2DM). The underlying mechanisms, however, remain unclear. The CD4 and CD8 cells play distinct pathogenic roles mediating type 1 diabetes. This clinical trial includes 40 patients with T2DM who underwent Roux-en-Y gastric bypass from 2009 to 2016. Duration of diabetes was $3 \pm 0,5$ years. Blood glucose and glycosylated haemoglobin were $9,1 \pm 0,5$ mmol/l and $7,1 \pm 0,2\%$, respectively. A part of the small bowel was taken for the histochemical examination. We report the preliminary postoperative follow-up data of $16,9 \pm 3,4$ months. Blood glucose and glycosylated haemoglobin were $5,8 \pm 0,3$ mmol/l and $5,9 \pm 0,2\%$, respectively. The histochemical exam emphasized the presence of a chronic inflammatory infiltrate in the lamina propria mostly constituted of CD4 and CD8 T lymphocytes. Both type 1 and type 2 diabetes can have a common pathogenic mechanism.

Keywords: gastric bypass, diabetes mellitus, inflammatory infiltrate

Nowadays obesity is a major medical and social problem, reaching high epidemic rates on a global scale, with more than 300 million obese people, medical costs representing 2–7 % from the total health expenses in developed countries [4]. According to the World Health Organization, obesity is now ranked on the second position of lethality, being preceded only by smoking [5]: over 220 000 people die every year in Europe and over 300 000 in the US [2]. During 1986–2000 the prevalence of BMI > 30 kg/m doubled, BMI $\geq$ 40 kg/m^2 increased four times and super obesity with BMI $\geq$ 50 kg/m^2 increased five times [6]. BMI was established as an independent risk factor for premature mortality [7].

The danger of morbid obesity depends on associated comorbidities that lead to decreased ability to work, disability and increased mortality in young people [3]. People suffering from morbid obesity carry major risk for the development of multiple comorbidities, such as type 2 diabetes (T2DM), arterial hypertension, hyperlipidemia, coronary artery pathology, obstructive sleep apnea, gastroesophageal reflux and hiatal hernia [20].

Metabolic disorders do not depend only on the excessive presence of adipose tissue, but also on its repartition, risk being increased in android distribution because of perivisceral deposition [22]. Associatied factors such as obesity, hypertension, dyslipidemia, impaired glucose tolerance or type II diabetes and hyperuricemia make up the metabolic syndrome or "X syndrome", inducing atherosclerotic risk factors due to the increase of tissue insulin resistance [2]. Multiple studies have found that the degree of obesity increases the risk of type II diabetes, particularly abdominal obesity [8]. This risk depends on the pathophysiological mechanisms that induce diminished insulin sensitivity, secondary decrease of B-cell function, and accordingly, hyperglycemia (glucotoxic) induction [9].

Insulin resistance is involved in the polycystic ovarian syndrome and non-alcoholic hepatic steatosis [9]. Recent studies have shown that obesity is associated with increased incidence and mortality through various types of cancer, which are directly correlated with body mass index. Obesity is not only linked with the incidence of cancer, but also affects survival and recurrence among those diagnosed [25].

Excessive storage of subcutaneous and visceral fat have a negative impact in determining the pulmonary mechanical restriction through ascension of the diaphragm and functional limitation of thorax, altering the compensatory mechanism of ventilation-perfusion followed by increasing pulmonary blood volume, creating prerequisites for the installation of congestive heart failure with hypoxemia, hypercapnia and compensatory hyperglobulia [10].

No less important are the psychological repercussions caused by social, familiar and conjugal discrimination, limited exercise and movement [11]. Cohabitation with the professional psychosocial stress is deficient, which is why its impact on health and quality of life is particularly [1]. Increased morbidity and mortality rates are registered in socially isolated persons, with high psychological morbidity among people lacking social support [12].

A high incidence of comorbidities and premature deaths are often determined, most frequently in patients with morbid obesity [11]. The mortality rates for people between 25–40 years who suffer from morbid obesity, is twelve times higher than for those with normal weight [3].

For a long time it was considered that obesity is an inevitable condition which does not affect health and can be solved by dietary and discipline [13]. Currently this concept has been rejected, being established that severe obesity is a lethal disease that cause worsening of existing pathologies and shortens life [11].

Most authors believe that the diversity of food behaviour in obese people is a direct cause of relapse [14]. Even an intensive program of lifestyle modification leads to modest weight loss [15]. Programs using very low calorie diets result in a loss of 15–25 % by weight after six months. However, the results are modest after a long period after the intervention: 9 % weight loss after one year and 5 % after four years [15]. Dietary and medical treatment, practicing physical exercises, improving food behaviour are ineffective in more than 95 %, requiring the approach of alternative methods of treatment [7].

Currently, bariatric surgery is the only solution capable of inducing substantial loss of body mass and reducing comorbidities [17]. There are multiple alternative methods of treatment, a high diversity of algorithms for surgeons and the decisions of patients become more and more risky [16]. It has been widely established that surgery is the only modern therapeutic solution in patients subjected to "caloric chronic poisoning" [17].

Materials and methods of research

The prospective study includes clinical examination and laboratory data of 122 patients with morbid obesity and metabolic disorders undergoing gastric bypass surgery between 2009–2016 at the Department of Surgery of "Sf. Arhanghel Mihail" Hospital of State University of Medicine and Pharmacy "Nicolae Testemitanu" and CSF "Galaxia". Selection of patients took place according to the NIH Consensus Conference guidelines (1991) criteria, with the presence of body mass index equal to or greater than 40 kg/m² or equal to and greater than 35 kg/m² in the presence of comorbidities. From the general group, 15 patients with BMI < 35 kg/m² and type 2 diabetes were submitted to gastric bypass. Patients were interviewed and investigated 1, 3, 6, 9, 12, 24, 36 and 60 months postoperatively.

Surgical methods

Open gastric bypass was performed by the retrocolic and antegastric route with 50–150 cm of biliopancreatic limb and 70–250 cm of alimentary limb. The pouch about 30 ml was created by stapling the stomach using a TA-90-4,8 B linear stapler. Gastrojejunostomy was created using hand-sewn technique with an anastomosis of 0,8–1,2 cm in diameter. Absence of leak was evaluated applying methylene blue solution through nasogastric tube. The mesenteric defect was closed with 2/0 continuous nonabsorbable suture to prevent development of internal hernias. Abdominal cavity drainage and nasogastric tube installation were mandatory.

Among patients with type 2 diabetes and BMI < 35 kg/m² the length of biliopancreatic loop was 100–150 cm.

Laboratory methods

Laboratory studies evaluated complete blood count and blood chemistry tests. To assess metabolic disorders, the lipid profile, carbohydrate metabolism tests, markers of systemic inflammation and hormonal status were taken. In order to emphasize carbohydrate metabolism disorders, impaired fasting glucose, glucose tolerance test, glycated haemoglobin, C-peptide concentration and serum insulin levels were performed.

Histochemical examination

In 42 cases (34,4 %) from the overall study group, a segment of the small bowel was taken at a distance of 50–150 cm from the Treitz ligament for histological examination, and in 31 cases (73,8 %) histochemical examination was performed.

Anthropometric data

There were studied weight loss, Body Mass Index (BMI), percentage of excess body weight loss (% EWL), percentage of excess body mass index loss (% EBMIL):

● BMI = weight/height²;

● % EWL (percentage of excess weight lost) = [(initial weight – current weight)/(initial weight – ideal weight)]·100;

● % EBMIL (percent of excess BMI loss) = 100 – [(current BMI – 25/IMC initially – 25·100].

Evaluation of results

There were assessed the incidence, remission, improvement of type 2 diabetes, as well as the evolution of lipid metabolism parameters.

According to ADA recommendations (American Diabetes Association), the criteria to appreciate the status of type 2 diabetes are: complete remission, fasting glucose <5,6 mmol/l (< 100 mg/dl) and HbA1c < 6,0 %; incomplete remission, fasting glucose ≥ 5,7 ≤ 6,9 mmol/l (100–125 mg/dl) and/or HbA1c ≥ 6,0 to 6,4 % over the year, in the absence of oral antidiabetic or insulin therapy. Clinical improvement was defined by the reduction of HbA1c (> 1 %) and fasting glucose (> 25 mg/dl), or by reducing the dose of administered drug. These criteria were assessed during 24 months after the intervention. Terms of reference were < 5,2 mmol/l for cholesterol (< 200 mg/dl) and < 1,7 mmol/l (< 150 mg/dl) for triglycerides.

Statistical methods

The statistical processing of the obtained data was performed using Microsoft® Excel software. To assess the difference between the compared values Student T-test was used. In this writing are discussed the data with not less than 95 % accuracy (p < 0,05).

Statistical dependence between the qualitative parameters was presented using contingency tables, and to verify the hypothesis of independence between rows and

columns Chi-square (X^2) criteria was used. P value < 0,05 was considered statistically significant.

Results of research and their discussion

From the total study group, 39 (31,9%) were men, 83 (68,1%) were women. Male/female ratio was 1:2. Age limit was between 19–68 years, with an average of 40,4 ± 0,9 years. Body weight ranged between 81 and 245 kg, with an average of 124,9 ± 2,6 kg. Body mass index was in the limits of 28,7 and 75,6 kg/m^2, with a mean of 44,4 ± 0,8 kg/m^2. According to body mass index, patients were divided into the following groups: BMI < 35 kg/m^2, BMI – 35–39,9, BMI – 40–49,9 and BMI ≥ 50 kg/m^2 (Table 1).

Weight loss

From the whole group of patients, 86 (70,4%) of them have been monitored 12 months after the intervention, 46 patients (37,7%) 3 years postoperatively and 13 patients (10,6%) 5 years postoperatively. The dynamics of weight loss were higher in the first three months after the intervention, %EWL being of 37,6 ± 1,2, which represents over 50% of weight loss registered one year postoperatively. Body weight after 12 months was 83,7 ± 1,9 kg, %EWL – 64,4 ± 1,7, %EB-MIL – 82,4 ± 3, and registered BMI was 29,6 ± 0,6 kg/m^2. After three years, %EWL and %EBMIL were 64,3 ± 2,4 and 82,5 ± 3,6 respectively, with a BMI of 29,1 ± 0,7 kg/m^2. Five years after the intervention, recorded %EWL, EBMIL% and BMI were: 64,4 ± 4,9; 78,3 ± 5,7 and 29,8 ± 1,4 kg/m^2 respectively. Twelve months postoperatively, %EWL was lower in the group of patients with super obe-

sity (BMI ≥ 50 kg/m^2) – 56 ± 4,1 compared to the group with morbid obesity (BMI-40 to 49,9) – 63,2 ± 2, but without a significant statistical difference (p > 0,05). Weight loss was higher in the group of patients with class II obesity (BMI – 35 to 39,9) –72 ± 4,3 compared to the group with super obesity (p < 0,05). In the group of patients with BMI <35 kg/m^2, %EWL was 68,9 ± 6,6, weight loss being similar to the group of patients with class II obesity (p > 0,05). For patients with BMI ≥ 60 kg/m^2 (n = 3), %EWL was 45,3 ± 14,1 twelve months postoperatively, in two cases being 19,52 and 48,34 respectively, which implies potentially reduced effectiveness of this procedure in this case (Table 2). Thus, in similar cases we have proposed the fitting of gastric bypass on 250 cm alimentary loop, but the results are premature.

Lipid profile

From the total study group, elevated cholesterol levels were found in 55 cases (45,8%), the average being 6,3 ± 0,1 mmol/l and hypertriglyceridemia in 44 cases (36%), with an average of 2,7 ± 0,3 mmol/l. Preoperative values of low-density cholesterol (LDL) were 4,5 ± 0,1 mmol/l, and the parameters of high-density cholesterol (HDL) were 0,86 ± 0,04 mmol/l respectively.

Postoperatively registered cholesterol values were 4,2 ± 0,1mmol/l (p < 0,001), triglycerides 1,2 ± 0,1 mmol/l (p < 0,001), and recorded parameters for LDL and HDL were 3 ± 0,3 mmol/l (p < 0,001) and 1,1 ± 0,5 mmol/l respectively (p < 0,01), which shows a significant statistical difference compared to initial parameters (Fig. 1).

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Table 1
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Variables	BMI < 35 (n = 15)	BMI ≥ 35 < 39,9 (n = 30)	BMI 40–49,9 (n = 48)	BMI ≥ 50 (n = 29)
Age (years)	45,6 ± 2,6‡	38,4 ± 1 , 8 †	41,1 ± l,6‡	40,3 ± 1,9
M/F	8/7	7/23	13/35	11/18
Weight (kg)	96,9 ± 2,4†	102,5 ± 2,1†	126 ± 2,1†	162,7 ± 5,4
BMI (kg/m^2)	32,2 ± 0,6†	37,3 ± 0,3†	44,8 ± 0,4†	57,7 ± 1,2
Cholesterol (n = 55) (mmol/1)	7 ± 0,6‡	6,0 ± 0,1‡	6,3 ± 0,1‡	6,3 ± 0,2
Triglycerides (n = 44) (mmol/1)	4,6 ± 2,1‡	2,9 ± 0,41‡	2,4 ± 0,1‡	2,2 ± 0,1
Basal glycemia (n = 40) (mmol/1)	11,9 ± 1,4#	9,0 ± 2,3‡	8,3 ± 0,4‡	7,7 ± 0,5
HbAlc (%)	8,3 ± 0,5#	6,7 ± 0,41‡	6,5 ± 0,2‡	6,7 ± 0,2
C peptide (ng/mL)	2,8 ± 0,2‡	5 ± 1,51‡	4,1 ± 0,4‡	3,4 ± 0,2
Serum insulin (цШ/mL)	26,4 ± 11,3‡	13,1 ± 8,2‡	31 ± 6,4#	9,5 ± 4,9

N o t e . Comparative values of the last columns with the previous ones: † – p < 0,001; # – p < 0,051; ‡ – p > 0,05.

Weight loss

Variables	BMI < 35	BMI ≥ 35 < 39,9	BMI 40–49,9	BMI ≤ 50
Weight (kg)	72 ± 2,6†	72,l ± 3,3†	83,9 ± 1,9*	101,7 ± 5,4
BMI (kg/m²)	24,8 ± 0,8†	26,4 ± l,2†	29,7 ± 0,5†	36,1 ± 1,5
% EWL	68,9 ± 6,6‡	72 ± 4,3#	63,2 ± 2‡	56 ± 4,1
% EBMIL	109,3 ± 15,7#	97,9 ± 7,2†	76,6 ± 2,5#	64,8 ± 4,5

N o t e . Comparative values of the last columns with the previous ones: * – p < 0,01; † – p < 0,001; # – *p* < 0,05; ‡ – p > 0,05.
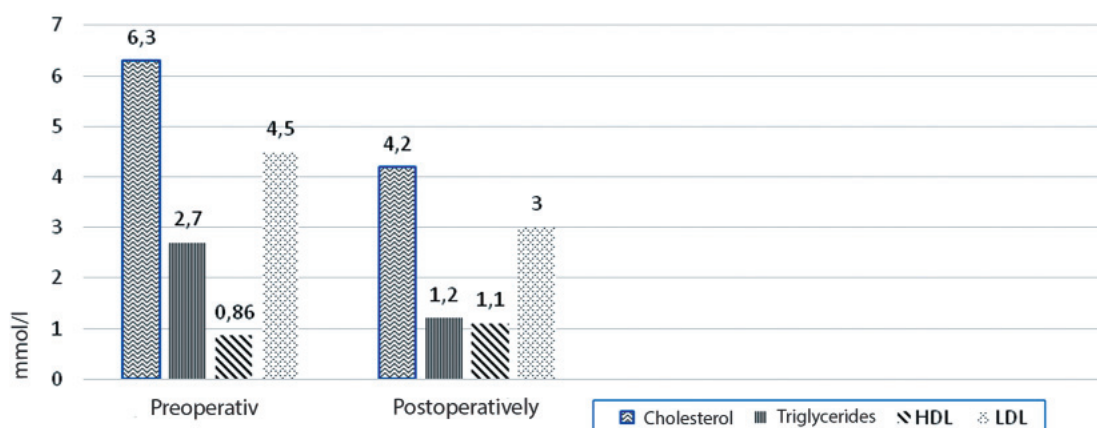

Fig. 1. Evolution of lipid metabolism parameters

Glucose homeostasis

All the cases showed the improvement of laboratory parameters with a significant statistical difference of fasting glucose and HbA1c. Start of glycemic control occured in the majority of cases three months after the intervention. Registered data of carbohydrate metabolism parameters in the general group were: 1 month – glycemia 6,7 ± 0,3 mmol/l, HbA1c – 6,5 ± 0,2 %; 3 months – glycemia 6,4 ± 0,3 mmol/l, HbA1c– 5,9 ± 0,2 %; 6 months – glycemia 6,0 ± 0,3 mmol/l, HbA1c – 5,7 ± 0,2 %; 9 months – glycemia 5,9 ± 0,3 mmol/l, HbA1c – 5,5 ± 0,2 % and 12 months – glycemia 5,8 ± 0,3 mmol/l, HbA1c – 5,9 ± 0,2 %.

Twenty-four months postoperatively, targeted parameters were: glycemia – 5,6 ± 0,03 mmol/l, HbA1c – 5,9 ± 0,4 %. From the total group of 40 (100 %) patients with disturbances of glucose homeostasis, remission occurred in 39 (97,5 %) cases and only in one case improving glucose metabolism was registered, without oral anti-diabetic administration. Complete remission was recorded in 21 (52,5 %) cases, being evaluated 12 months postoperatively.

From the total group of 40 patients with type 2 diabetes, 15 (37,5 %) patients had BMI < 35 kg/m² (28,7 to 34,7), with an average of 32,2 ± 0,6 kg/m². Body weight ranged from 84 to 112 kg, averaging 96,9 ± 2,4 kg. Duration of diabetes in this group was between 1–12 years, with an average of 3 ± 0,5 years. All the patients were receiving hypoglycemic drug, two of them insulin.

Preoperative fasting glycemia was in the limits of 6,4 and 21,37 mmol/l with an average of 11,9 ± 1,4 mmol/l and recorded limits of HbA1c were situated between 6,14 and 10,48 %, with an average of 8,3 ± 0,5 %. In all the cases it was found the endocrine function of the B-pancreas by evaluating the C-peptide and seric insulin levels that were 2,8 ± 0,2 ng/mL and 26,4 ± 11,3 μU/mL respectively (Table 1).

Postoperative results were spectacular: at one month, glycemia – 7,3 ± 0,5 mmol/l, HbA1c – 6,9 ± 0,4 %; three months, glycemia – 6,5 ± 0,5 mmol/l, HbA1c – 6,2 ± 0,3 %; at six months, glycemia – 6,9 ± 0,7 mmol/l, HbA1c – 6 ± 0,3 %; at nine months, glycemia – 6,5 ± 0,3 mmol/l, HbA1c – 5,9 ± 0,4 %; at 12 months, glycemia – 5,9 ± 0,4 mmol/l, HbA1c – 6 ± 0,1 % (Fig. 2).
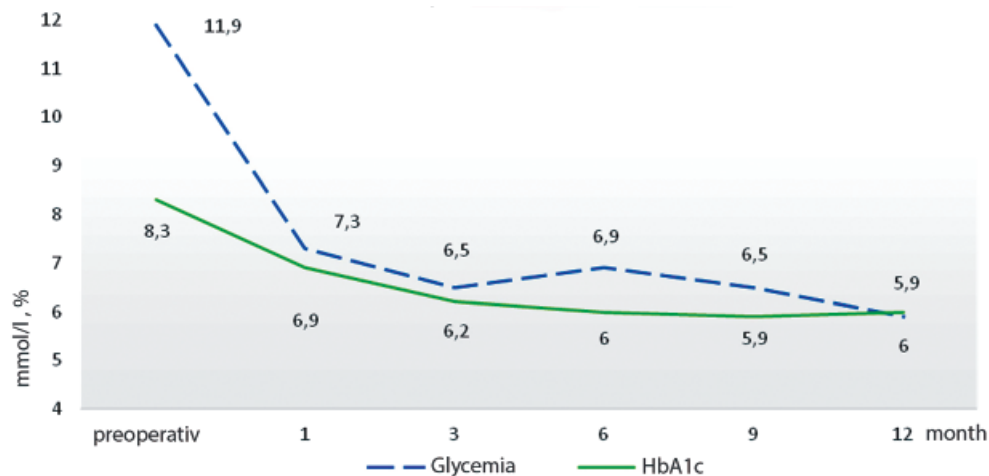
Fig. 2. Evolution of glycemic parameters (BMI < 35 kg/m^2)

Thus, remission occurred in all the cases (100%), including non-obese patients ($n = 2$) (BMI < 30 kg/m^2), with significant statistical difference (p < 0,001), the results being similar to the group of patients with morbid obesity (BMI ≥ 35 kg/m^2) in postoperative remission of type 2 diabetes (p > 0,05). In all the cases, medical treatment was suspended in the first postoperative days.

Histochemical examination results

Data analysis of histological examination revealed the small intestine with preserved histological structure and the presence of a rich chronic inflammatory infiltrate in corium which consisted of T lymphocytic elements, diffuse and nodular predominantly in patients with type 2 diabetes.

Histochemical examination revealed the presence of CD20: positive in nodular lymphoid aggregates and in rare cells scattered in diffuse inflammatory infiltrate. CD68: positive in macrophages corium frequencies. CD4/CD8 ratio was 1/2–8. From the total 31 patients this picture was present in 11 cases out of 14 investigated patients with diabetes compared to 2 patients with similar histochemical picture from the rest of the group ($X^2 = 14,072$; p < 0,005).

Discussions

Patients with morbid obesity (BMI > 35 kg/m^2) carry a major risk of developing multiple medical comorbidities, including diabetes, hypertension, hyperlipidemia, coronary artery disease, sleep apnea, gastroesophageal reflux and hiatal hernia [20]. The rate of obesity is increasing worldwide, as the number of bariatric procedures. These interventions lead to significant decrease in body mass, but also prevent comorbidities related to obesity, improving the quality of life and reducing the risk of premature death [21].

Among many bariatric procedures, gastric bypass was shown to be the most common intervention performed in patients suffering from morbid obesity [21]. The percentage of excessive weight loss (% EWL) at five years may reach in the limits of 60–70%, with long-term continuity [20]. These data correspond with the results of our study. However, it shows the reduced efficacy of this procedure in patients with BMI > 60 kg/m^2, described in other writings [24], which may require a procedure of increased malabsorption, such as long loop gastric bypass or biliopancreatic diversion.

However, the practice of these interventions can result into the installation of potentially dangerous metabolic disorders. In our study, we implemented gastric bypass on long alimentary loop (250 cm), but the results are premature. Thus, choosing a safe and effective procedure in the case of a super obese patient remains the dilemma of the surgeon as well as of the anesthesiologist team. Researchers are in the process of finding the ideal surgical procedure, with a minimum rate of complications that would lead to sufficient weight loss, thus increasing the expectancy and improving the quality of life [23].

Recent studies showed the profound impact of bariatric surgery on improving clinical

manifestations of type 2 diabetes in obese patients [27]. Two procedures, gastric bypass and the biliopancreatic diversion are the most effective approaches in the treatment of diabetes, in comparison with other procedures, and they lead to normal concentration of serum glucose, insulin and glycated haemoglobin in 80-100 % of the obese patients [19]. Buchwald et al., on a systematic study and analysis of bariatric interventions of English publication conducted between 1990 and 2006, showed improvement or complete remission of diabetes in 87 % of patients, and failure in diabetes remission or its improvement were justified by the duration and preoperative severity of the disease [21]. This remarkable effect can reduce the installation of possible complications, especially of the cardiovascular system [25].

The decrease of peripheral resistance to insulin and improvement of non-alcoholic hepatic steatosis associated with body weight loss is believed to cause the remission of type 2 diabetes. On the other hand, despite the regain of body mass, the presence of a considerable improvement suggests that there are other mechanisms that affect the glycemic control in the long-term data, such as alteration of gastrointestinal hormones function and disruptions in brain gut axis induced by anatomical change of digestive tract after surgery [26]. However, despite certain results showing the improve of glucose homeostasis in most patients with type 2 diabetes after gastric bypass, the responsible mechanisms for its improvement remain uncertain [21].

An accepted theory of the rapid improvement of glucose homeostasis after gastric bypass is the exaggerated release of insulin tropic hormones, gastric inhibitory polypeptide (GIP) and glucagon-like peptide-1 (GLP-1) being primarily targeted [21]. Improvement of residual beta cell function may be observed in a short period after the intervention and increase over time, probably due to increased incretin effect and reduced glucotoxicity. According to a hypothesis, proximal small intestine bypass would reduce the release of some unknown factors of intestinal segment having inhibitory action on beta cells. It is suggested that the contact exclusion of food and duodenum may be due to a decreased or absent response of one or more duodenal hormones that function as inhibitors of incretin insulin tropic agents, hormones known as anti-incretin [28].

Currently there are two most reliable competing theories in diabetes remission after bariatric interventions: the theory of proximal jejunum (foregut theory) and the theory of terminal ileum (hindgut theory) [18]. The first provides inhibition of "putative" signals that are responsible for inducing insulin resistance or difficult controlling of glucose metabolism, the consequence being the exaggerated release of insulin tropic hormone, especially the GIP. The cause of the improvement of glucose metabolism in terminal ileum theory is the exaggerated bowl transit of undigested food which induce "L" cell stimulation with active GLP-1 release.

However, remission of type 2 diabetes is common also for restrictive interventions that do not lead to the exclusion from transit of the duodenum and incipient jejunum.

Some recent studies on post-mortem extracted pancreas in patients with type 1 diabetes show the same histochemical picture present in our study [29]. Type 1 diabetes is an immune-mediated disease emerging from the selective destruction of pancreatic beta cells due to infiltration of the islets of Langerhans cells of the immune system. A rich inflammatory infiltrate in lymphocytes is observed in pancreatic islets. Thus, it is suggested that the cause of type 1 diabetes is the invasion of lymphocytes in the pancreatic islets, predominantly CD8 cytotoxic T-cells, triggering an autoimmune inflammatory process characterized by reversing the CD4/CD8 ratio. The infiltrate ("insulitis") consists mainly of CD8+ T-cells, plus a variable number of CD4+ T-cells and macrophages. CD4+ cells are present in all the patients' islets, but less abundant than CD68+ or CD8+ cells. Natural cells "killer" were rarely found in the islets, even in advanced inflammatory processes. This means that both CD8+ cytotoxic cells and macrophages contribute to beta cell death during initiation of inflammatory process. CD20+ cells are present in a small number in the early phase of inflammation, increasing during the advancing of the process [29].

These data are similar to the histochemical examination of our study. Thus, both type 1 and type 2 diabetes may have the same pathogenic mechanism in origin, the difference being only the action on the "target" cells. In our view, the inflammatory autoimmune process at the level of jejunal mucosa could be the unknown anti-incretin factor responsible for the jam of the incretin area with perturbation of insulin tropic hormones responsible for glucose homeostasis. Thus, the start of autoimmune inflammatory process in the small bowel could be caused by chronic ingested food substance capable of inducing autoimmune inflammatory reactions in some susceptible individuals. If we consider this theory, then we could explain the common mechanism of diabetes remission for

all the bariatric interventions, both restrictive and derivative.

Remission of diabetes after restrictive interventions appears to be due to the severe decrease of small bowel contact with the concerned "allergen" food substance and in case of derivative interventions – the exclusion of contact with incretin area. Meanwhile, superior remission of biliopancreatic diversion in comparison with gastric bypass could be caused not by a more pronounced malabsorption, but rather the exclusion from the transit of a significant segment of the small bowel. These data are confirmed by higher postoperative results in the appearance of diabetes remission after mini-gastric bypass intervention, which provides for the exclusion from the transit of over 200 cm of small intestine [30].

By implementing the gastric bypass on biliopancreatic loop of 100–150 cm in our study, in patients with BMI < 35 kg/m^2 and type 2 diabetes, the achieved remission rate was 100%, inclusively in the case of two patients being insulin dependent. These data show the efficacy of the intervention given to patients with mild obesity (30–35 kg/m^2) as well as its potential for non-obese patients ($n = 2$) (BMI < 30 kg/m^2) in postoperative remission of type 2 diabetes.

Conclusions

This study has shown that gastric bypass surgery is effective in the treatment of morbid obesity and metabolic syndrome. In super obesity patients, the results are encouraging but still require optimization of biliopancreatic and food loop length. Promising, lasting results are obtained in the surgical treatment of type 2 diabetes regardless of BMI. Both type 1 diabetes and type 2 diabetes can have a common pathogenic mechanism.

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