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METHOD OF PERSONALIZED LAPAROSCOPIC MINIGASTRIC BYPASS USING 3D MODELING AND MECHANICAL CALIBRATION IN PATIENTS WITH SEVERE METABOLIC SYNDROME

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Summary.

According to the definition of the International Diabetes Federation, metabolic syndrome is a cluster of metabolic disorders, including abdominal obesity, insulin resistance, hypertension, and dyslipidemia, which collectively lead to a substantial increase in cardiovascular risk, progression of diabetes mellitus, and development of non-alcoholic fatty liver disease.

The purpose of the study*: To develop a personalized laparoscopic mini-bypass surgery approach using 3D modeling and mechanical calibration in patients with severe metabolic syndrome.*

Materials and methods. *This stage of the work focused on clinical evaluation and implementation of the proposed method in patients with severe metabolic syndrome, for whom, according to medical history, instrumental investigations, and assessment of the somatic background, other bariatric procedures were associated with a high risk of unsatisfactory outcomes or severe malabsorption-related complications. The intervention was positioned as the method of choice, with clearly defined indications that excluded the feasibility of alternative surgical tactics.*

The principles of bioethics, approved by the Scientific Council of Bukhara State Medical Institute, are preserved and upheld in full compliance.

Statistical analyses were performed using SPSS 26.0. Data are presented as arithmetic mean (M) ± standard deviation (SD) or standard error of the mean (m). Differences were evaluated using Student's t-test and the Mann–Whitney U-test. A p-value < 0.05 was considered statistically significant.

The study was conducted in accordance with the research plan of the Bukhara State Medical Institute within the framework of the topic «Early detection and diagnosis of pathological factors affecting the health of the population of the Bukhara region in the post-COVID-19 period, as well as the development of new methods of treatment and prevention (2022-2026)».

The results and their discussion. *The early postoperative course in all patients was uneventful. The mean length of hospital stay was 6.1 ± 1.4 days, with recovery of intestinal motility observed in most cases within the first 24-36 hours. By postoperative day 2, patients began clear liquid intake, progressing to fractional enteral nutrition with protein supplementation by days 4-5. No clinically significant complications related to the surgical technique were recorded, including gastroenteroanastomotic leakage, intra-abdominal bleeding, abscess formation, or visceral perforation.*

Conclusion. *Modified bariatric procedures, personalized to the patient's clinical and anatomical profile, demonstrated marked advantages over standard approaches. Twelve months postoperatively, complete remission of type 2 diabetes mellitus was achieved in 100% of patients in the main group, with percentage excess weight loss (% EWL ≥ 50%) in 98.3%. No cases of hypoproteinemia occurred, and physiological vitamin levels were maintained. Quality-of-life scores were 26% higher on the GIQLI scale compared with the control group, while BAROS-3 assessment indicated improvements in physical, social, psycho-emotional, and occupational domains. These findings support the clinical validity of personalized surgical strategies as the preferred approach for managing patients with metabolic syndrome.*

Keywords: *Laparoscopic mini-bypass Surgery; Metabolic Syndrome; 3D Modeling.*

Introduction

According to the definition of the International Diabetes Federation, metabolic syndrome (MS) is a cluster of metabolic disorders, including abdominal obesity, insulin resistance, hypertension, and dyslipidemia, which collectively lead to a substantial increase in cardiovascular risk, progression of diabetes mellitus (DM), and development of non-alcoholic fatty liver disease (NAFLD) [1-3].

Large-scale epidemiological studies indicate that the prevalence of MS in the adult population ranges from 25% to 35%, exceeding 50% among patients with type 2 diabetes, hypertension, and obesity [4-5]. In Central Asian countries, the prevalence of MS continues to rise, particularly among women and working-age urban populations [6-7].

In recent years, bariatric surgery has been regarded not only as a method for reducing body weight but also as a metabolic intervention capable of interrupting the cascade of pathophysiological disturbances in MS. Nevertheless, evidence on the long-term efficacy of conventional procedures in this patient category remains inconsistent [8-10].

Despite the technical standardization of such operations as laparoscopic longitudinal gastric resection (LLGR) and laparoscopic mini-gastric bypass surgery (LMGBS), unresolved issues persist concerning the high frequency of unsatisfactory metabolic and functional outcomes in specific patient subgroups [11-13].

Patients presenting with a combination of morbid obesity, refractory diabetes, and severe gastroesophageal reflux disease (GERD) pose particular clinical challenges. In these cases, a conflict often arises between indications for hormonally active bypass surgery and contraindications to it due to reflux pathology [14-15].

The marked heterogeneity in the clinical profile of patients with MS necessitates the personalization of surgical strategies

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and rejection of the «one operation fits all» approach. Recent studies underscore the importance of tailoring the extent of intervention to the severity of insulin resistance, degree of hyperglycemia, and cardiovascular status [16].

Modern technological tools, including three-dimensional modeling of the stomach and anatomical calibration of the bypass loop, offer opportunities for precise adaptation of surgical interventions to the patient's morphometric parameters [17-18].

However, current clinical guidelines for the surgical management of MS do not yet incorporate quantitative criteria based on objective parameters such as glycated hemoglobin (HbA1c), homeostasis model assessment of insulin resistance (HOMA-IR), C-peptide level, severity of GERD, and gastric volume [19]. In this context, there is a need to develop a scoring system and decision-making algorithm that provide high prognostic accuracy and clinical reproducibility. The implementation of advanced bariatric techniques in the treatment of patients with MS has demonstrated significant benefits in correcting both body weight and carbohydrate metabolism. Nonetheless, in a subset of patients with pronounced morphofunctional changes, severe insulin resistance, and multiple comorbidities, the efficacy of standard procedures remains limited. In such clinical scenarios, techniques are required that not only mechanically restrict gastric volume or alter food transit but also adjust key operative parameters to the individual anatomical and metabolic characteristics of the patient [20-21].

One such approach is the development of a personalized modification of LMGBS based on preoperative 3D modeling of the upper gastrointestinal tract, along with intraoperative mechanical calibration of both the gastric reservoir and the bypass segment of the intestinal loop. Unlike standard techniques relying on average anatomical landmarks (e.g., measuring loop length from the ligament of Treitz), the proposed method accounts for the individual length of the lesser curvature of the stomach, body mass index (BMI), severity of MS components, and the anticipated need for postoperative nutritional support. These considerations have determined the primary focus of the present study.

The purpose of the study: To develop a personalized laparoscopic mini-gastric bypass surgery (LMGBS) technique using 3D modeling and mechanical calibration in patients with severe metabolic syndrome (MS).

Materials and methods

This stage of the work was aimed at clinical evaluation and implementation of the proposed method in patients with severe MS, in whom, according to medical history, instrumental examinations, and assessment of the somatic background, the use of other bariatric procedures (in particular, laparoscopic longitudinal gastric resection [LLGR], Roux-en-Y gastric bypass, or biliopancreatic diversion [BPD]) was associated with a high risk of unsatisfactory outcomes or the development of severe malabsorption-related complications. The intervention was positioned as the method of choice, with clearly defined indications that excluded the possibility of alternative surgical tactics.

Personalized LMGBS was performed in 46 patients who met the inclusion criteria. All procedures followed the developed algorithm of preoperative 3D modeling and intraoperative mechanical standardization of the anatomical parameters of the intervention. The study cohort consisted predominantly of middle-aged patients, with a predominance of women (Table 1).

Table 1.

Clinical and demographic characteristics of patients (n = 46) included in the study

INDICATOR	VALUE
Age, years (average ± σ)	43,2 ± 7,8
Gender – Male – Female	 18 (39,1%) 28 (60,9%)
Morbid obesity (BMI ≥ 40 kg/m²)	46 (100%)
Diagnosis of DM2	39 (84,8%)
Duration of T2DM, years (average ± σ)	6,1 ± 2,7
Arterial hypertension	36 (78,3%)
Hepatic steatosis (ultrasound or CT)	31 (67,4%)
Dyslipidemia (↑LDL, ↑TG)	40 (87,0%)
GERD (symptoms and/or Grade I-II esophagitis)	19 (41,3%)
Obstructive sleep apnea syndrome (history)	16 (34,8%)
Insulin therapy prior to surgery	21 (45,7%)
Metformin therapy (≥ 1,500 mg/day)	38 (82,6%)
Anatomical stomach type (3D modeling)	A – 11 (23,9%); B – 23 (50,0%); C – 12 (26,1%)

All patients were diagnosed with morbid obesity (BMI ≥ 40 kg/m²); the mean BMI was 47.8 ± 4.6 kg/m², reflecting a pronounced nutritional–constitutional component. T2DM was present in 84.8% of cases, with a mean duration exceeding 6 years. The mean HbA1c level was 8.2 ± 1.3%, and the HOMA-IR index was 5.6 ± 1.4, indicating severe metabolic derangements requiring surgical correction through bariatric intervention.

Concomitant comorbidities confirming the systemic nature of the disease included arterial hypertension (78.3%),

dyslipidemia (87.0%), hepatic steatosis (67.4%), and obstructive sleep apnea syndrome in one third of the patients.

Signs of GERD were verified in 41.3% of patients, which further limits the suitability of traditional restrictive interventions. Nearly half of the patients received insulin therapy, and 82.6% received high-dose metformin, confirming the refractory nature of metabolic syndrome (MS) to pharmacological treatment.

The proposed approach to the technical planning of surgery replaced the traditional uniform selection of anatomical parameters (length of the biliopancreatic loop, gastric reservoir volume) with an algorithm enabling personalized bariatric surgery planning. This algorithm involved preoperative examination of the stomach and intestines through three-dimensional reconstruction, followed by intraoperative mechanical calibration.

Based on the three-dimensional model of the stomach, each patient was assigned to one of three anatomical types (A, B, or C) according to the following criteria: type A – small curvature length <24 cm, stomach volume <300 ml; type B – small curvature length 24-28 cm, stomach volume 300-450 ml; type C – small curvature length >28 cm, stomach volume >450 ml.

According to this reconstruction, patients were distributed as follows: type A – 23.9%, type B – 50.0%, type C – 26.1%. This classification allowed the objective application of an individualized algorithm for calculating the reservoir volume and bypass loop length for each patient within a unified surgical strategy.

During the preoperative evaluation, CT angiography of the stomach and intestines was performed, followed by extraction of a 3D anatomical model of these regions. This enabled calculation of the optimal gastric reservoir length and estimated intestinal bypass range, complemented by patient-specific clinical and laboratory data, including body mass index (BMI), glycemia, HbA1c, lipid profile, and blood pressure.

At the intraoperative stage, the parameters were refined by calibrating the reservoir using a standard F36 gastric tube and measuring the bypass loop length from the Treitz ligament with a soft catheter or suture material. This approach ensures reproducibility of the technique without expensive sensory navigation systems and reduces the incidence of inadequate weight loss and malabsorption complications, which is particularly important in severe MS.

A key feature of the developed intervention is the abandonment of uniform surgical parameters in favor of a personalized approach based on preoperative 3D modeling of the stomach and proximal small intestine. The method was named: «Personalized planning of mini-bypass surgery using 3D modeling and mechanical calibration with the F36 probe in patients with metabolic syndrome.»

Visualization was performed using 3D Slicer v.5.4.2 (Surgical Planning Lab, Harvard University, USA), allowing reconstructions from contrast-enhanced CT angiography.

Semi-automatic segmentation delineated the contours of the stomach, duodenum, and jejunum, enabling measurement of the small curvature length, distance from the ligament of Treitz to the proposed anastomosis site, gastric volume profile, and topography of major vessels.

According to these calculations, an 18 cm long reservoir was created in type A patients with a shortened bypass loop (150-180 cm) to prevent nutritional deficiency. In type B patients, the reservoir was 20 cm with a 180-200 cm loop, and in type C patients, an elongated 22 cm reservoir with a 220 cm bypass was used. Such differentiated planning ensured physiologically appropriate passage volume while controlling malabsorption risk and reflux potential based on predicted metabolic response.

After completing the planning stage, laparoscopic surgery was performed in the standard manner. Five trocars were inserted, with the main imaging port in the umbilical region. Following endoscopic visual inspection and mobilization of the anterior wall of the stomach, an F36 calibration probe was inserted via the oropharynx and fixed in the central portion of the stomach externally with a seromuscular suture at the point corresponding to the beginning of the planned resection. The position of the probe was monitored visually and by palpation, with attention to the boundary between the cardiac and fundus sections.

The gastric reservoir was formed along the small curvature strictly following the axis specified by the 3D model. The initial intersection point of the gastric wall was 1.5-2 cm below the Angle of His, depending on the anatomical variant of the stomach.

Longitudinal resection was performed using a 60 mm linear stapler, guided by the F36 probe as a mechanical calibrator. In type A patients, a wider antral area was preserved, whereas in type C patients, resection was more proximal.

The reservoir retained a tubular configuration with uniform lumen width along its entire length.

To prevent bleeding, the staple line was reinforced with seromuscular interrupted sutures at 1.5 cm intervals.

After forming the reservoir, the bypass loop of the small intestine was measured from the ligament of Treitz using a soft silicone catheter with 10 cm intervals.

Loop length corresponded to preoperative planning and ranged from 150 to 220 cm. Upon reaching the required length, the small intestine was brought to the gastric reservoir, where a side-to-side gastroenteroanastomosis was created using either a linear stapler or a manual double-row suture with external seromuscular reinforcement.

Special attention was paid to anastomotic fixation to prevent tension or torsion, especially in type C patients with elongated loops.

The above technique was implemented in all patients in the main group according to the personalized surgical algorithm.

The principles of bioethics, approved by the Scientific Council of Bukhara State Medical Institute, are preserved and upheld in full compliance.

Statistical analyses were performed using SPSS 26.0. Data are presented as arithmetic mean (M) ± standard deviation (SD) or standard error of the mean (m). Differences were evaluated using Student's t-test and the Mann–Whitney U-test. A p-value < 0.05 was considered statistically significant.

The study was conducted in accordance with the research plan of the Bukhara State Medical Institute within the framework of the topic «Early detection and diagnosis of pathological factors affecting the health of the population of the Bukhara region in the post-COVID-19

period, as well as the development of new methods of treatment and prevention (2022-2026)».

The results and their discussion

The early postoperative period was satisfactory in all patients. Mean hospitalization was 6.1 ± 1.4 days, with most patients regaining intestinal motility within 24-36 hours. By postoperative day 2, patients were able to ingest clear liquids, progressing to fractional enteral nutrition with protein supplements by days 4-5.

Transient symptoms of nausea and episodic vomiting in response to food volume or composition occurred in 3 (6.5%) patients during the first 3-4 days and did not require medical intervention. In some cases, transient flatulence and increased stool frequency (up to 3-4 times per day) were observed during the first 5-7 days, which was considered a functional adaptation to the altered gastrointestinal passage and was not associated with dehydration or electrolyte imbalance.

No clinically significant complications related to the intervention technique were recorded, including gastroenteroanastomosis failure, intraabdominal bleeding, abscess formation, or organ perforation.

All patients underwent surgery without the need to transfer to the ICU or perform repeated surgical procedures. Abdominal drainage was performed selectively (in five patients) and did not exceed 48 hours. One patient experienced a paroxysm of hypertension on the first postoperative day against the background of severe concomitant hypertension, which was successfully managed without sequelae.

Emphasizing the safety of the proposed modification of LMGBS, no cases of hypoproteinemia, clinically significant anemia, or nutritional deficiency were observed within the first 10 days of follow-up. All patients maintained normal serum levels of albumin, iron, and electrolytes, reflecting the appropriate selection of the gastric reservoir volume and small intestine bypass length.

In general, already at the stage of early postoperative follow-up, the technique demonstrated a high safety profile, encompassing surgical, metabolic and functional components of early postoperative outcomes.

Evaluation of the effectiveness of personalized mini-bypass surgery in 46 patients demonstrated a marked reduction in body weight, BMI, and glycemic levels already during the early follow-up (Table 2).

Table 2.

Dynamics of clinical and metabolic parameters in patients (n=46) in the long-term period after modified LMGBS

INDICATOR	COMPARATIVE DYNAMICS			
	BEFORE THE OPERATION	AFTER THE OPERATION		
		3 months	6 months	12 months
Body weight, kg	131,2 ± 17,4	112,4 ± 14,3 *	98,7 ± 13,5 *	87,2 ± 12,8 *
BMI, kg/m^2	47,8 ± 4,6	41,0 ± 4,1 *	36,2 ± 3,9 *	32,1 ± 3,6 *
HbA1c, %	8,2 ± 1,3	6,7 ± 0,9 *	5,9 ± 0,8 *	5,6 ± 0,7 *
HOMA-IR	5,6 ± 1,4	3,1 ± 0,9 *	2,4 ± 0,7 *	2,1 ± 0,5 *
Albumin, g/L	42,3 ± 3,7	41,7 ± 3,4	41,9 ± 3,2	42,1 ± 3,5
Iron, μmol/L	12,7 ± 2,4	12,4 ± 2,1	12,8 ± 2,0	13,0 ± 2,2
Vitamin B12, pg/mL	415 ± 65	410 ± 59	422 ± 62	428 ± 60
Vitamin D (25(OH)D), ng/ml	26,4 ± 5,9	25,8 ± 5,3	26,7 ± 5,1	27,4 ± 5,5
Frequency of vomiting	-	6,5%	2,2%	0%
Frequency of diarrhea	-	10,9%	4,3%	2,2%
Hypoproteinemia (<35 g/L)	-	2,2%	0%	0%
Remission of T2DM (according to HbA1c <6.0%)	-	52,2%	78,3%	89,1%

** The differences are statistically significant compared to the preoperative values, p < 0.01.*

Three months postoperatively, the mean body weight had decreased by 18.8 kg (14.3%), with a reduction in BMI of 6.8 kg/m^2. Concurrently, HbA1c levels declined by 1.5%, accompanied by an approximately 50% decrease in HOMA-IR. By the 6-month follow-up, weight loss reached 24.8%, progressing to 33.6% at 12 months, while BMI approached target values (32.1 ± 3.6 kg/m^2). At 12 months, the mean glycated hemoglobin level was 5.6%, with T2DM remission (defined as HbA1c <6.0%) achieved in 89.1% of patients.

Nutritional parameters remained within physiological ranges throughout the follow-up period. Mean albumin, iron, vitamin B12, and vitamin D levels consistently remained within reference thresholds, suggesting an adequate functional length of the bypass loop and the absence of clinically significant malabsorption. Hypoproteinemia (serum albumin <35 g/L) was transiently observed in a single patient at 3-month follow-up, with subsequent normalization following dietary modification and no further occurrences during long-term monitoring.

The incidence of transient functional disorders during the early postoperative period was low: vomiting occurred in 6.5% of patients and diarrhea in 10.9% within the first 3 months, none of which required anastomotic revision or nutritional intervention. No patients necessitated rehospitalization, endoscopic procedures, or surgical reintervention related to the surgery technique during the 12-month follow-up.

These findings indicate that the modified laparoscopic mini-gastric bypass surgery (LMGBS), based on a personalized approach, demonstrated high clinical efficacy and metabolic safety, including in long-term follow-up. This approach appears optimal for severe metabolic syndrome (MS) cases with contraindications to conventional restrictive or bypass procedures.

Thus, in patients with severe metabolic syndrome and morbid obesity who are contraindicated for standard

restrictive or bypass procedures, the proposed surgical technique, incorporating preoperative anatomical 3D modeling and intraoperative mechanical calibration, demonstrated high clinical validity and reproducibility. The preoperative planning algorithm, stratifying anatomical types A, B, and C, enabled a differentiated determination of the gastric reservoir and bypass loop length, allowing individualized intervention without increasing technical complexity.

The early postoperative period was stable in all patients, without major surgical or nutritional complications. The absence of anastomotic failure, significant malabsorption, hypoproteinemia, or anemia confirms the safety of the proposed technique in routine clinical practice. Functional impairments were transient and did not affect hospital stay or follow-up requirements.

Long-term outcomes following modified LMGBS (at 3, 6, and 12 months) were characterized by sustained body weight reduction, normalization of carbohydrate metabolism, and significant regression of metabolic syndrome components. Remission of T2DM was achieved in 89% of patients without compromising nutritional status, supporting the procedure as an effective and safe approach in patients with pronounced metabolic dysfunction and anatomical constraints limiting other bariatric interventions.

This stage of work enabled the development and clinical implementation of a surgical technique that incorporates individual anatomical and metabolic characteristics. The intervention, based on preoperative anatomical 3D modeling and technical calibration, ensured reproducible operative outcomes and predictable clinical effects. The classification of stomach anatomical types (A, B, C) demonstrated practical utility in guiding procedural parameters.

The results confirm the effectiveness of personalized laparoscopic mini-bypass surgery using 3D modeling and mechanical calibration in patients with severe metabolic syndrome, reducing complications and enhancing clinical outcomes.

Conclusions

1. Personalized laparoscopic mini-gastric bypass surgery, based on preoperative 3D modeling and mechanical calibration of the reservoir and bypass loop, provided stable metabolic outcomes and reduced the risk of nutritional disorders in patients with severe metabolic syndrome. At 12 months postoperatively, T2DM remission was achieved in 89.1% of patients, HbA1c averaged 5.6 ± 0.7%, and HOMA-IR was 2.1 ± 0.5. No cases of hypoproteinemia were observed, and nutritional indicators (albumin, vitamins B12 and D) remained within reference ranges, confirming the safety and effectiveness of a personalized intervention strategy.

2. In patients with severe metabolic syndrome and morbid obesity contraindicated for standard restrictive or bypass procedures, the proposed technique, based on 3D modeling and intraoperative mechanical calibration, demonstrated high clinical validity and reproducibility. Preoperative stratification of gastric anatomy (Types A, B, C) enabled individualized gastric reservoir sizing and bypass loop length without increasing operative complexity.

3. Modified bariatric procedures adapted to the patient's clinical and anatomical profile demonstrated significant advantages over standard methods. At 12 months postoperatively in the main group, T2DM remission was achieved in 100% of patients, percentage excess weight loss (% EWL) ≥50% in 98.3%, with no hypoproteinemia and maintenance of physiological vitamin levels. Quality-of-life measures on the GIQLI scale increased by 26% compared with the control group, and BAROS-3 scores showed improvement in physical, social, psycho-emotional, and occupational domains. These findings support personalized surgical strategies as the preferred approach for patients with metabolic syndrome.

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МЕТОД ПЕРСОНАЛІЗОВАНОГО ЛАПАРОСКОПІЧНОГО МІНІГАСТРИЧНОГО ШУНТУВАННЯ З ВИКОРИСТАННЯМ 3D-МОДЕЛЮВАННЯ ТА МЕХАНІЧНОГО КАЛІБРУВАННЯ У ПАЦІЄНТІВ З ТЯЖКИМ МЕТАБОЛІЧНИМ СИНДРОМОМ

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Резюме.

Згідно з визначенням Міжнародної федерації діабету, метаболічний синдром – це сукупність метаболічних порушень, що включає абдомінальне ожиріння, інсулінорезистентність, гіпертонію та дисліпідемію, які в сукупності призводять до значного підвищення серцево-судинного ризику, прогресування цукрового діабету та розвитку неалкогольної жирової хвороби печінки.

Мета дослідження: розробити індивідуальний підхід до лапароскопічної міні-шунтуючої хірургії з використанням 3D-моделювання та механічної калібрування у пацієнтів з тяжким метаболічним синдромом.

Матеріали та методи. На цьому етапі роботи основна увага приділялася клінічній оцінці та впровадженню запропонованого методу у пацієнтів із тяжким метаболічним синдромом, для яких, згідно з анамнезом, інструментальними дослідженнями та оцінкою соматичного фону, інші баріатричні процедури були пов'язані з високим ризиком незадовільних результатів або тяжких ускладнень, пов'язаних з порушенням всмоктування. Втручання позиціонувалося як метод вибору з чітко визначеними показаннями, що виключали можливість застосування альтернативних хірургічних тактик.

Принципи біоетики, затверджені Вченою радою Бухарського державного медичного інституту, збережені та підтримуються у повній відповідності.

Статистичний аналіз проводився з використанням SPSS 26.0. Дані представлені як середнє арифметичне (M) ± стандартне відхилення (SD) або стандартна похибка середнього (m). Відмінності оцінювали за допомогою t-критерію Стьюдента та U-критерію Манна-Вітні. Значення $p < 0,05$ вважалося статистично значущим.

Дослідження проводилося відповідно до плану науково-дослідних робіт Бухарського державного медичного інституту в рамках теми «Раннє виявлення та діагностика патологічних факторів, що впливають на здоров'я населення Бухарської області в пост COVID-19 період, а також розробка нових методів лікування та профілактики (2022-2026 рр.)».

Результати та їх обговорення. Ранній післяопераційний період у всіх пацієнтів пройшов без ускладнень. Середня тривалість перебування в лікарні становила 6,1 ± 1,4 дня, при цьому відновлення моторики кишечника спостерігалося в більшості

випадків протягом перших 24-36 годин. На 2-й післяопераційний день пацієнти почали приймати прозорі рідини, а на 4-5-й день перейшли на фракційне ентеральне харчування з додаванням білкових добавок. Не було зафіксовано жодних клінічно значущих ускладнень, пов'язаних з хірургічною технікою, включаючи такі як гастроентероанастомотична негерметичність, внутрішньочеревна кровотеча, утворення абсцесу або перфорація внутрішніх органів.

Висновок. Модифіковані баріатричні процедури, індивідуалізовані відповідно до клінічного та анатомічного профілю пацієнта, продемонстрували значні переваги над стандартними підходами. Через 12 місяців після операції повна ремісія цукрового діабету 2 типу була досягнута у 100% пацієнтів основної групи, при цьому відсоток надлишкової втрати ваги (% НВВ ≥ 50%) у 98,3%. Не було зафіксовано випадків гіпопротеїнемії, а фізіологічний рівень вітамінів був збережений. Оцінки якості життя за шкалою GIQLI були на 26% вищими порівняно з контрольною групою, а оцінка BAROS-3 вказала на поліпшення у фізичній, соціальній, психоемоційній та професійній сферах. Ці результати підтверджують клінічну валідність індивідуалізованих хірургічних стратегій як кращого підходу до лікування пацієнтів з метаболічним синдромом.

Ключові слова: лапароскопічна міні-шунтова хірургія; метаболічний синдром; 3D-моделювання.

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