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ALGORITHM OF THE DIAGNOSIS AND TREATMENT OF ENTERAL INSUFFICIENCY SYNDROME IN PERITONITIS

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RELEVANCE. The early diagnosis and correction of enteral insufficiency syndrome influence the treatment outcomes in patients with abdominal sepsis and multiple organ failure.

The OBJECTIVES was to improve the effectiveness of diagnosis and correction of enteral insufficiency syndrome in patients with generalized peritonitis using the express assessment scale of the severity of enteral insufficiency and the treatment algorithm based on this.

MATERIALS AND METHODS. The express assessment scale of the severity of enteral insufficiency syndrome was developed along with the treatment algorithm depending on the detected degree for systematic approach to the management of patients with generalized peritonitis. The study included 39 patients with generalized peritonitis (GP) who had received treatment in the Surgery Department of Samara Regional Clinical Hospital named after V. D. Seredavin in the period of 2019–2020. A computational program was created for quick severity evaluation of enteral insufficiency syndrome and choosing the best treatment strategy.

RESULTS. When comparing the severity of enteral insufficiency in patients immediately after the first operation and in 96 hours, a positive dynamics was registered: the number of patients with III degree of severity of enteral insufficiency syndrome decreased from 19 to 4 people, and the number of patients with I degree of severity of enteral insufficiency syndrome changed from 3 to 29 people, this indicated the stabilization of the condition of patients with GP ($p<0.05$). The statistically significant reduction in the number of points in the limits of each severity was evaluated as the proof of clinical efficacy of the algorithm applied for the enteral insufficiency syndrome correction ($p<0.05$).

CONCLUSION. Due to the correct choice of the treatment algorithm according to the identified severity of enteral insufficiency syndrome, the regression of clinical signs of generalized peritonitis was registered in all patients on the 5th postoperative day (96 hours after surgery).

Keywords: *generalized peritonitis, enteral insufficiency syndrome, endogenous intoxication, express assessment scale, treatment algorithm, computational program*

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Introduction. In the emergency abdominal surgery, the most difficult cases are met in the group of patients with generalized peritonitis (GP). The relevance of this problem is confirmed by high mortality rates, which are 20–30 %, and with the development of abdominal sepsis reach 90 % [1]. The leading role in the development of multiple organ failure in GP is played by the enteral insufficiency syndrome (EIS), the main cause of which is intestinal paresis with impaired motor and evacuation functions due to the source of intoxication and the development of peritonitis [2]. The next links in the pathogenesis of EIS are violations of the secretory, absorption, immune and barrier functions of the small intestine with the translocation of bacteria and toxins from the intestinal lumen into the abdominal cavity and systemic blood flow, which becomes the leading source of endogenous intoxication.

The early diagnosis and management of progressing entheropathy is the crucially significant stage in the treatment of patients with GP [3, 4]. The clinical manifestation of EIS has no pathognomonic

symptoms and, as a rule, is «masked» by the typical signs of generalized peritonitis: vomiting with a stagnant discharge, bloating, lack of peristalsis and defecation, or, conversely, multiple liquid defecation, tachycardia, tachypnea, encephalopathy [5]. Prompt determination of the severity of EIS affects the results of treatment of patients with GP [6]. For timely diagnosis and adequate treatment, it is important to determine the severity of EIS not only by the level of a certain indicator of endotoxicosis and intestinal stasis, but also on the basis of a comprehensive assessment of the results of clinical, laboratory, and instrumental research methods.

The disadvantages of EIS diagnosing methods are their complexity of use in wide clinical practice [7] and late receipt of test results (on the average, from 3 to 5 days), which does not allow to obtain an operational assessment of the dynamics of the pathological process and to carry out its timely and pathogenetically justified correction.

Yu. M. Gain et al. [8] in 2001, attempted to develop an effective, multifactorial, easy to use evaluation scale. Nevertheless, the presented scale requires the laboratory tests, including the wide range of immunological indicators, which take a long time to perform.

In this regard, the scale proposed by Yu. M. Gain was revised and improved by the authors. It served the basis of our own express assessment scale and computational program.

The **objective** of the study was to improve the effectiveness of diagnosis and correction of enteral insufficiency syndrome in patients with generalized peritonitis using the express assessment scale of the severity of enteral insufficiency and the treatment algorithm based on this. The following tasks were necessary to achieve this goal: to determine the most indicative criteria for EIS with the method of expert assessment and to form the scale for express diagnosis of the severity and dynamics of the syndrome; to create the computational program for EIS diagnosis allowing for the automatic process of calculation of indicators and choice of optimal treatment algorithm; to develop the algorithm for the EIS correction depending on the severity and to evaluate its clinical efficiency.

Methods and materials. The method of expert assessments determined the search of the most significant criteria of EIS diagnosis and creation of the express assessment scale for the syndrom's severity and dynamics in generalized peritonitis. We carried out the calculation of the required number of experts to obtain representative results according to the formula:

$$n=Nt^2pV/\Delta^2N+t^2pV,$$

where n – the number of experts to be involved for expert assessment; N – the number of the general totality; t – the confidence coefficient depending on the probability with which the sampling accuracy is guaranteed, with the probability of an errorless sign P=0.95; t =2; p – the share of the studied sign; V=(1–p), while the unknown pV is replaced by its maximum value – 0.25 (at p=0.5); Δ – the maximum (specified) sampling error 0.05.

According to the calculation results, 25 experts were involved in the study. The selection criteria for the experts were: job position (Head of the Surgery Department, Deputy Chief physician for surgery, Associate professor, Professor, Head of the Chair of surgery), work experience (more than 10 years), the highest qualification category in the specialty «Surgery», an academic degree and academic title (Candidate or Doctor of Medical Sciences, Associate professor, Professor). The criteria were evaluated on a 5-point scale, where 0 points were assigned when there was no the required indicator and 5 points were assigned when the indicator had its maximum value. The sum of these indicators reflected the coefficient of competence measured in points:

$$Ki=Pi+Ei+Si+Ci,$$

where Ki – coefficient of competence of the i-th expert; Pi – job position (points); Ei – academic degree and academic title (points); Si – work experience (points); Ci – qualification level of an expert (points). The maximum number of points that each expert could score was 500. On average, the experts gained Ki=(483.0±10.1) points (from 470 to 500 points). Thus, the competence coefficient of the experts included in the study was regarded as high.

The experts reviewed the offered clinical, laboratory and instrumental criteria (more than 100 in total) that characterized the main pathogenetic components of EIS – endogenous intoxication and paresis of the small intestine. The experts assigned from 1 to 3 points for each criterion, depending on its value in the EIS diagnosis, that corresponded to I, II, III degrees of severity of enteral insufficiency. Using the statistical processing, we identified 15 most valuable criteria of EIS and formed express assessment scale of the severity and dynamics of EIS. Each degree of severity of enteral insufficiency had its point interval: I degree – from 1 to 15 points, II degree – from 16 to 30 points, III degree – from 31 to 45 points.

To identify the correlation between the developed express assessment scale and the scale proposed by Yu. M. Gain et al., a clinical prospective study was conducted. It included 39 patients with secondary generalized peritonitis, who were receiving treatment in the Surgery Department of the Samara Regional Clinical Hospital named after V. D. Seredavin in the period of 2019–2020.

The inclusion criteria were: the diagnosis of secondary generalized peritonitis, a patient's informed voluntary consent, the age over 18 years. The exclusion criteria were: a concurrent oncopathology, systemic blood diseases, acute oral poisoning, congenital and acquired immunodeficiency conditions, and the age older than 70 years. The study was conducted in accordance with the requirements of the Helsinki Declaration of the World Medical Association.

All patients were admitted to the hospital and underwent the urgent surgery. This group of patients included 19 men and 20 women of mean age of (42.2±13.4) years. The causes of peritonitis were the following: acute intestinal obstruction (in 12 cases, 30.7 %), perforation of gastric and/or duodenal ulcers (in 11 patients, 28.2 %), necrosis of the small intestine (in 7 people, 17.9 %), in 5 patients (12.8 %) the GP developed due to pancreonecrosis, and in 4 (10.4 %) – the cause of GP was the destructive appendicitis.

After surgery, the abdominal cavity index according to V. S. Savelyev [1] was calculated for all the patients to define the indications for a programmed sanation relaparotomy.

After determining the severity of enteral insufficiency using the developed express assessment scale, all the patients were prescribed treatment according to the developed algorithm, which included surgical tactics, as well as the volume and modes of infusion, enteral, and detoxification therapy depending on the detected degree of severity of enteral insufficiency.

To combine the diagnostic and therapeutic approaches to the management of patients with GP, a computational program for a doctor's personal computer was created. The program has a multiplatform environment and is implemented using the languages Ruby, Rails framework, HTML 4.01, Database, JavaScript, Russian patent for computational program No. 2019612419 [9]. The program uses the express assessment scale for evaluation the severity and dynamics of enteral insufficiency and suggests the choice of the optimal treatment algorithm. Medical information is protected by providing an access to the program through the doctor's personal account.

STATISTICA 6.0 software was used for data analysis. We used the criteria of χ^2 (when analyzing four-field tables in several cells, the expected phenomenon took a value less than 10, for further analysis we used the exact Fisher criterion) and the Student's t-test. The McNemar's test was used when comparing two related populations (the result «before or after»). The average values are presented through mathematical expectation and standard deviation (M±s).

Results. After statistical processing of the data obtained from the expert group, the 15 criteria for enteral insufficiency syndrome were identified and the express assessment scale of the severity and dynamics of EIS was formed (*fig. 1*).

Each criterion had a score corresponding to the I, II or III degree of the severity of enteral insufficiency, and was assigned to one of the four diagnostic blocks of the scale – clinical, laboratory, instrumental, or intraoperative.

To identify the statistical differences between the developed express assessment scale and the prototype scale, the severity of enteral insufficiency was evaluated in all patients after the first operation (*table 1*).

Spearman's correlation coefficient (p) is 0.973. The correlation between the studied characteristics – direct, the closeness (strength) of correlation on Chaddock scale is high. The number of degrees of freedom (f) is 37. The critical value of Spearman's criterion for the given number of degrees of freedom is 0.317, and the correlation of characteristics is statistically significant ($p<0.05$).

The sensitivity, i.e. the proportion of true positive cases, was calculated in relation to the Yu. M. Gain scale using the following formula:

$$Se=TP/(TP+FN)100\ \%.$$

The specificity, i. e. the proportion of true negative cases that were correctly identified by the scale, was calculated using the formula:

$$Sp=TN/(TN+FP)100\ \%,$$

where TP (True Positives) – correctly classified positive examples; TN (True Negatives) – correctly classified negative examples; FN (False Negatives) – positive examples classified as negative (a type I error). 63 FP (False Positives) – negative examples classified as positive (a type II error). The sensitivity of the developed express assessment scale was 88.1 %, and the specificity was 62.5 %.

Taking into account the absence of statistically significant differences in the frequency of each degree of severity of enteral insufficiency determined by both scales, we concluded that it is possible to apply the express assessment scale developed by the authors further in clinical practice.

The abdominal cavity indexes (ACI) calculated in all patients during the first laparotomy were the following: in 3 (7.7 %) patients, the ACI was up to 10 points (on average, (9.33±2.1)), and in 36 (92.3 %) patients, the ACI was 13 or more points (on average (13.08±1.35) points), which was an indication for the programmed sanation relaparotomy in these patients within 24 hours after the first operation.

The ACI calculation data corresponded to the results of assessing the severity of enteral insufficiency with the developed express assessment scale: 36 people (92.3 %) had II or III degree, which, in the absence of positive dynamics, confirmed the progression of GP and served as an indication for the sanation relaparotomy. After the first laparotomy, the treatment was corrected according to the developed algorithm, which is shown in *fig. 2*.

To correct EIS, we proposed an algorithm that included the use of oxygen barotherapy at certain time intervals, enterosorption, optimal compositions of metabolic environments for enteral nutrition, the necessary volumes of infusion therapy (based on the calculated formulas for critically ill patients), as well as methods of systemic detoxification.

According to the classification of V. M. Luft et al. (2002), nutritional support (NS) of critically ill patients is divided into actual, auxiliary and artificial [11]. The task of the current NS is to enhance the effect of therapeutic diet therapy by introducing additional highly nutritious enteral mixtures. Auxiliary NS is focused on eliminating metabolic (micronutrient) enteral insufficiency. This type of NS should be started intraoperatively, continuing in the early postoperative period until the appearance of stable active intestinal peristalsis. Auxiliary NS is the main type of support for patients on the first day of the postoperative period, allowing the delivery of nutrients to enterocytes without additional energy expenditure, which reduces the probability of detachment of healthy epithelial cells of the intestinal membrane and «prepares» the patient's intestines for enteral mixtures. Artificial NS is carried out in the form of enteral nutrition (enteral mixtures) and parenteral administration of nutrients. The type, method and speed of administration of enteral mixtures and parenteral nutrition were determined based on the degree of severity of EIS (I or II), guided by the protocols developed by V. M. Luft. Preference was given to fully balanced standard polymer mixtures for enteral feeding with the sip method and the three-in-one concept for parenteral nutrition. One of the main factors causing the formation of intestinal paresis is local and systemic hypoxia. This process leads to a disbalance between the oxidative and antioxidative systems and the accumulation of lipid peroxidation products

Assessment criteria	0 Score	1 Score	2 Score	3 Score
Peritonitis prevalence (intraoperative)	No peritonitis	Local peritonitis or abdominal abscess	**	Generalized peritonitis
Peritoneal exudate (intraoperative)	No exudate	Sulfuric exudate	Hemorrhagic exudate	Squid or purulent or ferment exudate
Intestinal status (intraoperative)	Norm	Bloating of the intestinal loops and/ or single independent peristalsis	Infiltration of the intestinal wall and/or lack of spontareous and stimulated peristalsis	Intestinal fistula and/ or anastomosis failure
Fibrin overlaps (intraoperative)	No	Single fibrin overlaps	«Carapace» type of fibrin overlaps	Fibrin as a loose mass
Festering or necrosis of the surgical wound	No	**	**	Yes
Source of infection (causes of peritonitis) in the abdominal cavity	Removed, no exudation	**	Source of infection is site eliminated and/or exudation present.	Source of infection area cannot be removed during the first operation
Hypoalbuminemia, g/l	50–35	34–28	27–20	≤19
Stagnant discharge by nasointestinal (nasogastric) tube, millilitres per day*	No	<800	800–1500	>1500
Peristalsis of the intestine	Peristalsis ispreserved, active	Peristalsis ispreserved, single	Peristalsis is induced	No peristalsis
Radiological signs of intestinal paresis	No	**	Pneumatosis	The presence of «bowls» and «arches»
Vomiting	No	Single vomiting with light discharge	**	Repeated vomiting by stagnant discharge
Intraabdominal pressure, mmHg	7–11	12–15	16–20	≥21
Serum potassium	3.5–5.1	5.2–5.5 3.4–3.0	5.6–6.9 2.9–2.5	>7 ≤2,4
Defecation	Regular	Liquid defecation up to 2 times or no defecation for more than 24 hours with normal peristalsis	Liquid defecation 3 to 7 times a day or lack of defecation for over a day with sporadic peristalsis перистальтике	Liquid defecation >8 times a day or no defecation and no peristalsis for more than 2 days
C-reactive serum protein, mg/l	<5	≤100	100–200	>200

*Fig. 1. Express assessment scale of the severity of EIS: * – these indicators are determined based on the average values of the volumes of empty (<800 ml), filled (800–1500 ml), stretched (>1500 ml) by liquid contents of the stomach; ** – the absence of districtors corresponding to 1 and 2 points is connected either with a similar approach in the scale of criteria for intraoperative assessment of the nature of abdominal lesions in peritonitis (abdominal index), developed by V. S. Saveliev and co-author [10], or with the specifics of expert assessments received from respondents*

Table 1

A frequency of various degrees of severity of enteral insufficiency determined by the developed express assessment scale and the prototype scale

Degree of severity of enteral insufficiency	Number of patients with the appropriate degree of enteral insufficiency	
	on the developed express assessment scale	on the prototype scale*
I	3	5
II	17	15
III	19	19

* – the correction factor *K* was applied.

I degree	II degree	III degree
Surgical tactics 1. Decompression of the upper gastrointestinal tract: Nasogastric tube (NG tube) insertion behind the ligament of Treitz; 2. Method of closing the abdominal cavity: possible layer-by-layer suturing; Sanitation mode: relaparotomy on demand. **Infusion therapy** • Central venous pressure (CVP) control Volume 1500 + (body weight – 20)·15 ml • Additionally: Succinic acid (Reamberin 400 ml), intravenously, 2 times per day. **Enteral therapy** Starts intraoperatively. 1. Intestinal tube lavage up to 3 times/day (Single volume Sol. NaCl 0.9 % 200 ml); 2. Intestinal tube sorption up to 3 times/day – Enterosgel / polysorb (Single dose of 15 g + Sol. NaCl 0.9 % 400 ml. Exposure up to 40 min); 3. Intestinal tube oxygen therapy (Single volume up to 700 ml, velocity 80 ml/min); up to 3 times /day. Exposure up to 10 min; Intra-abdominal pressure (IAP) control 2–3 times/day **Artificial Nutritional Support (Enteral Nutrition):** • The presence of NG tube is compulsory. • Peristalsis is not present: water up to 300 ml; • Peristalsis available: water up to 500 ml/day. • Enteral nutrition (sipping). Evaluation of glucose electrolyte sample. >50 % return – conversion to metabolic feeding <50 % return – reception of enteral mixtures in the amount of 5–10 ml/min, calorage 40–50 kcal/day	**Surgical tactics** 1. Epidural anesthesia / Novocain block of the mesentery of the small intestine; 2. Stomach decompression (NG tube); 3. Small intestine decompression (intestinal tube); 4. Formation of laparostoma (skin suturing), redraining of abdominal cavity. Sanitation mode: by programme **Infusion therapy** • Central venous pressure (CVP) control Volume 1500 + (body weight – 20)·15 ml • Additionally: Succinic acid (Reamberin 800 ml), intravenously, 2 times per day. • Prophylactic dose use of anticoagulants **Enteral therapy** Starts intraoperatively. 1. Intestinal tube lavage (Single volume Sol. NaCl 0.9 % 1000 ml) up to 2–3 times/day. 2. Intestinal tube sorption up to 3 times /day – Enterosgel / polysorb (Single dose of 15 g + Sol. NaCl 0.9 % 200 ml. Exposure up to 40 min); 3. Prevention of ascending bacterial contamination: nifuroxazide. Once a day (Single volume 5 ml + Sol. NaCL 0.9 % 100 ml) Exposure up to 60 min. 4. Intestinal tube oxygen therapy – Intra-abdominal pressure (IAP) control! (Single volume up to 700 – 1500 ml, velocity 80 ml / min), up to 3 times / day. Exposure up to 20 min. **Auxiliary Nutritional Support (metabolic feeding)** – do not wait for peristalsis! Single volume: Sol. Glucosae 5 % – 400 ml + glutamic acid 2–3 g+ + Omega 3 polyunsaturated fatty acids 15 ml, up to 3 times a day. Exposure up to 60 min. **Artificial nutrient support (enteral feeding, parenteral feeding)** The presence of NG tube is compulsory. Water up to 250 ml/day (sipping) Enteral power supply: Evaluation of glucose electrolyte sample: >50 % return – metabolic feeding <50 % return – reception of enteral mixtures in the volume of 5 ml/min, 60 kcal/day. • **Parenteral nutrition** • **Hyperbaric oxygenation** **1–10 sessions**	**Surgical tactics** 1. Search for focus of infection, control of intestinal tube position; 2. Epidural anesthesia / Novocain block of the mesentery of the small intestine; 3. Stomach decompression (NG tube); 4. The formation of laparostoma (open abdomen technique); 5. Redraining of abdominal cavity. Sanitation mode: by programme. **Infusion therapy** • Central venous pressure (CVP) control • Volume 1500 + (body weight – 20)·15 ml • Additionally: Succinic acid (Reamberin 800 ml), intravenously, 2 times per day. • The use of anticoagulants in therapeutic doses Correction of antibacterial therapy (evaluation of the result of sowing from the abdominal cavity) **Enteral therapy** Starts intraoperatively. 1. Intestinal tube lavage (Single volume Sol. NaCl 0.9 % 1000 ml) up to 4 times/day. 2. Intestinal tube sorption up to 3 times/day – Enterosgel/polysorb (Single dose of 15 g + Sol. NaCl 0.9 % 200 ml. Exposure up to 40 min). 3. Prevention of ascending bacterial contamination: nifuroxazide. (Single volume 5 ml + Sol. NaCL 0.9 % 100 ml) up to 3 times/day. Exposure up to 60 min. 4. Intestinal tube oxygen therapy – Intra-abdominal pressure (IAP) control! (Single volume up to 700 ml, velocity 80 ml/min), up to 2 times/day. Exposure up to 20 min. **Auxiliary Nutritional Support (Metabolic Nutrition)** – not to wait for peristalsis. Single volume: Sol.Glucosae 5 %–400 ml + glutamic acid 2–3 g + Omega 3 polyunsaturated fatty acids 15 ml, up to 3 times a day. Exposure up to 60 min. **Artificial nutrient support (enteral feeding, parenteral feeding):** • The presence of a NG tube is compulsory. • Water up to 250 ml/day (siping) • Parenteral feeding. **Hyperbaric oxygenation 1–10 sessions** **Extracorporeal detoxification**

Fig. 2. Treatment algorithm for different severity of enteral insufficiency

in the tissues, which have a cytotoxic effect. An effective group of drugs that affect the stabilization of intracellular metabolism, in particular, the process of biological oxidation, are succinic acid preparations («Reamberin», «Remaxol») [7].

The microcirculation of intestinal villi has features of the anatomical structure, which determine the development of early oxygen starvation of cells: most of the blood oxygen (up to 80 %) is shunted from arterioles to venules, without reaching the apex of the villi. This leads to a decrease in oxygenation of the mucous membrane of the gastrointestinal tract, death of enterocytes, violation of the integrity of the intestinal barrier [12]. In 1980, Academician A. M. Ugolev proposed and then proved the hypothesis of the possibility of direct consumption of oxygen by enterocytes from the intestinal lumen [13]. Consequently, we consider the implementation of intestinal oxygen therapy under

Table 2

Dynamics of EIS in patients with GP in treatment according to the developed algorithm

Degree of severity of enteral insufficiency	Number of patients with the appropriate degree of enteral insufficiency	
	on the 2nd day after the first operation	on the 4th day after the first operation
I	13	29
II	17	6
III	9	4
In total	39	39

Table 3

Dynamics of the average values of points for three degrees of EIS after the first operation and on the 4th day of the postoperative period

Degree of severity of enteral insufficiency	Dynamics of the average values of points for EIS		Value of t, p
	after the first operation	on the 4th day after surgery	
I	(13.31±1.38)	(9.21±1.82)	t=7.43; p<0.000001
II	(23.76±1.44)	(16.33±1.51)	t=9.77; p<0.000001
III	(37.22±1.39)	(31.00±0.82)	t=9.16; p=0.000004

the control of intra-abdominal pressure indicators to be one of the perspective methods for correcting the severity of EIS.

Pathological changes in the rheological properties of the blood are detected as early as 12 hours after the patient develops GP, and by the end of the first day, a pronounced sludge syndrome and blockage of the microvascular bed by blood aggregates develops. On days 2–3, patients with GP develop acidosis, hemolysis in the capillaries, and local increase in blood clotting, which creates prerequisites for the development of disseminated intravascular coagulation syndrome [14, 15]. Therefore, the treatment algorithm provided for the use of drugs with anticoagulant action.

The surgical tactics of the developed algorithm implied staged sanitization of the abdominal cavity, prevention (treatment) of the abdominal compartment syndrome, and the use of the «open abdomen» technique. For this, vacuum-assisted dressings were used to form the laparostomy. This technique was used in 2 patients of the main group with III degree of severity of EIS and signs of intractable intestinal paresis. After sanation relaparotomy, the abdominal drains were ligated to exclude air aspiration into the abdomen under the vacuum system. On the surface of the adjacent intestinal loops, a perforated silicone plate was placed, on top of which a large-cell foam rubber was placed. The laparostoma was sealed with a film, in which a window was cut for the port connecting the dressings and the set. Replacement was performed at its depressurization or on the day of the following relaparotomy.

The optimal interval between enteral therapy sessions is 4–6 hours. After the first laparotomy, the severity of enteral insufficiency was determined in all patients and treatment regimens were prescribed according to the developed algorithm; the effectiveness of treatment was assessed 48 and 96 hours after the operation. The lack of positive dynamics on the 4th day of the postoperative period was one of the signs of progressive multiple organ failure and endotoxicosis, which required correction of the treatment.

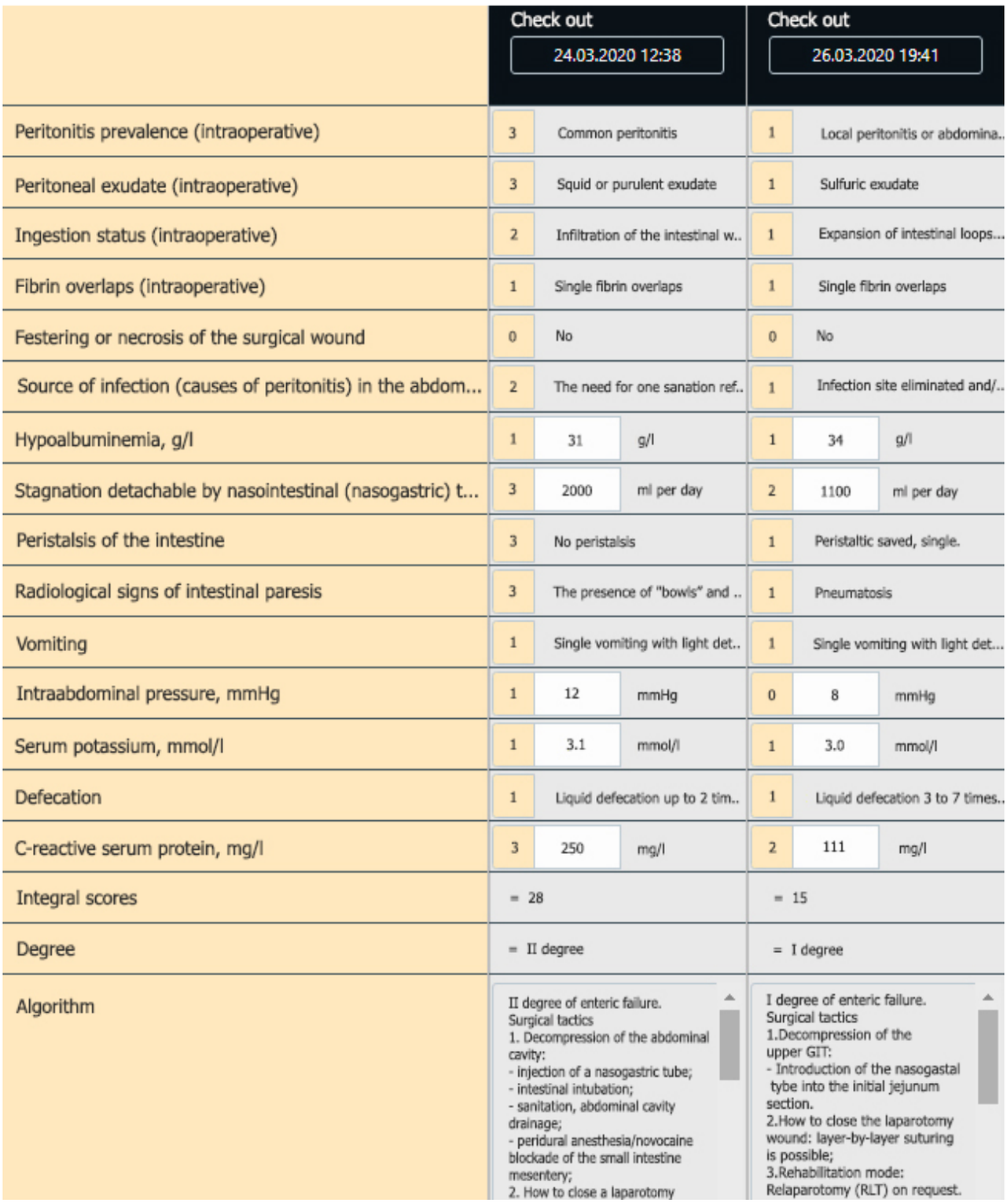
The subsequent results of assessing the severity and dynamics of EIS on the 2nd and 4th days after the first operation are presented in *table 2*.

In 9 (23.1 %) patients in 48 hours after surgery (on day 2), there was no positive dynamics in reducing the degree (points) of enteral insufficiency. In these patients, the ACI after the sanation relaparotomy was (13.08±0.92) points, which was an indication for relaparotomy, sanation of the source of infection in the abdominal cavity, monitoring of the effectiveness of intubation probe functions, and prevention of compartment syndrome. After the relaparotomy, the severity of enteral insufficiency in these patients was re-determined, taking into account the intraoperative data, and the prescribed treatment was corrected in accordance with the developed algorithm.

When comparing the severity of EIS in patients immediately after the first operation and in 96 hours (postoperative day 4), a positive dynamic was registered: the number of patients with III degree of enteral insufficiency decreased from 19 to 4 people ($p<0.05$), and the number of patients with I degree of enteral insufficiency increased from 3 to 29 people, ($p<0.05$). This fact indicated the stabilisation of GP clinical and laboratory indicators.

In determining the average values of points in each severity of enteral insufficiency, the following results were obtained (*table 3*).

The statistically significant reduction in the number of points in the limits of each degree of severity of enteral insufficiency was evaluated as the proof of clinical efficacy of the algorithm applied for the EIS correction.



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Peritonitis prevalence (intraoperative)	3 Common peritonitis	1 Local peritonitis or abdomina..
Peritoneal exudate (intraoperative)	3 Squid or purulent exudate	1 Sulfuric exudate
Ingestion status (intraoperative)	2 Infiltration of the intestinal w..	1 Expansion of intestinal loops...
Fibrin overlaps (intraoperative)	1 Single fibrin overlaps	1 Single fibrin overlaps
Festering or necrosis of the surgical wound	0 No	0 No
Source of infection (causes of peritonitis) in the abdom...	2 The need for one sanation ref..	1 Infection site eliminated and/..
Hypoalbuminemia, g/l	1 31 g/l	1 34 g/l
Stagnation detachable by nasointestinal (nasogastric) t...	3 2000 ml per day	2 1100 ml per day
Peristalsis of the intestine	3 No peristalsis	1 Peristaltic saved, single.
Radiological signs of intestinal paresis	3 The presence of "bowls" and ..	1 Pneumatosis
Vomiting	1 Single vomiting with light det..	1 Single vomiting with light det...
Intraabdominal pressure, mmHg	1 12 mmHg	0 8 mmHg
Serum potassium, mmol/l	1 3.1 mmol/l	1 3.0 mmol/l
Defecation	1 Liquid defecation up to 2 tim..	1 Liquid defecation 3 to 7 times..
C-reactive serum protein, mg/l	3 250 mg/l	2 111 mg/l
Integral scores	= 28	= 15
Degree	= II degree	= I degree
Algorithm	II degree of enteric failure. Surgical tactics 1. Decompression of the abdominal cavity: - injection of a nasogastric tube; - intestinal intubation; - sanitation, abdominal cavity drainage; - peridural anesthesia/novocaine blockade of the small intestine mesentery; 2. How to close a laparotomy	I degree of enteric failure. Surgical tactics 1.Decompression of the upper GIT: - Introduction of the nasogastal tybe into the initial jejunum section. 2.How to close the laparotomy wound: layer-by-layer suturing is possible; 3.Rehabilitation mode: Relaparotomy (RLT) on request.

Fig. 3 Interface of the computational program based on the developed express assessment scale and the algorithm for the EIS correction

In 2 out of 6 patients with preserved III degree by the 5th day of the postoperative period, further examination revealed the presence of extraabdominal foci of infection (septic pneumonia). After additional specific treatment in these patients, the II degree of severity of enteral insufficiency was determined on the 6th day of the postoperative period.

The mortality rate was 10.3 %, and 4 patients died. The cause of death in 3 patients was the progressive multiple organ failure, in 1 patient – acute heart failure.

For automatic evaluation of the severity of enteral insufficiency and the choice of appropriate therapy for patients with generalized peritonitis, a computa-

tional program was created, the interface of which is shown in *fig. 3*.

The time spent on the processing of a patient data to determine the severity of enteral insufficiency was on average (16.72±2.77) minutes, when using the developed program for a personal computer – (6.77±1.96) minutes, with the statistically significant difference (Student's t-test =8.29, p<0.000001). Thus, it was possible to reduce the time for examining the patient and making a decision on the appropriate treatment algorithm by 2.5 times.

The use of the scale allowed for saving each examination in the patient's diary and thus to analyse the dynamics of EIS in different time intervals, reducing the time required to determine the severity of enteral insufficiency and prescribe the appropriate treatment.

Discussion. When describing the changes in the small intestine in generalized peritonitis, many authors note two pathological processes underlying the appearance of EIS – endotoxicosis and impaired passage of intestinal content. As GP is progressing, the endogenous intoxication takes on a persistent noncurable character, and intestinal paresis from reflex becomes pathological. The impact on the components of the «vicious circle» of EIS can affect the development of GP.

One of the important tasks of this work was to establish the value of the studied clinical and laboratory criteria in the diagnosis of EIS.

Despite the presence of clear signs of small intestine dysfunction in GP, there are no pathognomonic symptoms to determine the severity of enteral insufficiency. Therefore, to decide that the chosen surgical tactics is correct, the treatment is effective and the patient's condition is objectified, it is necessary not only to determine the presence of EIS, but also to evaluate the severity and dynamics of this syndrome, which is possible when using express assessment scales.

All patients were admitted to the Surgical Department in SRCH n. a. V. D. Seredavin with varying severity of GP and intestinal insufficiency. The effectiveness of treatment of patients with GP depended on a differentiated approach to the EIS correction. Indicators of a decrease in the severity of intestinal insufficiency were considered: the appearance of active sustained intestinal peristalsis, the decrease in the volume of stagnant discharge through intestinal (nasogastric) probe, the normalization of intra-abdominal pressure, the appearance of independent defecation, the decrease in the level of C-reactive protein, the reversing of hypoalbuminemia.

The research suggested: express assessment scale of the severity of EIS; algorithm of the EIS correction depending on the identified severity; a program for a personal computer that allows to reduce the time spent on determining the severity of EIS.

The implementation of the proposed program for determining the severity of EIS and the algorithm for its correction improved the treatment results in patients with GP, which consisted in the reduction of the severity of EIS on the 3rd–5th days of the postoperative period, as well as the stabilization of the main clinical and laboratory indicators of endotoxicosis and generalized peritonitis.

Conclusion. 1. The severity and dynamics of enteral insufficiency in patients with generalized peritonitis can be defined by evaluating the 15 most important criteria included in the express assessment scale.

2. The express assessment scale developed by the authors has a high correlation with the known assessment scales of the severity of EIS, while its sensitivity is 88 %, specificity is 62 %.

3. The differentiated tactics of patient's treatment, taking into account the severity and dynamics of EIS, implies an optimal program of infusion therapy, enteral detoxification and oxygen therapy. The early restoration of peristalsis and the enteral nutrition contribute to the improvement of treatment results in this category of patients.

4. The computational program for assessing the severity of EIS allows to choose the optimal treatment algorithm for patients, as well as reduces the time spent on evaluation of the severity of enteral insufficiency.

Conflict of interest

The authors declare no conflict of interest.

Compliance with ethical principles

The authors confirm that they respect the rights of the people participated in the study, including obtaining informed consent when it is necessary, and the rules of treatment of animals when they are used in the study. Author Guidelines contains the detailed information.

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