Research Article

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Surgical Aspects of the Treatment of Patients with Generalized Peritonitis

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BACKGROUND Much attention is currently given to the issues of surgical treatment of common forms of secondary peritonitis, which is associated with unsuccessful results of treatment of this group of patients and the lack of a unified approach to surgical tactics among patients requiring repeated surgical interventions for adequate sanitation of the abdominal cavity.

AIM OF STUDY Improvement of the immediate results of treatment of patients with generalized secondary peritonitis by determining the approaches to choosing the optimal surgical tactics.

MATERIAL AND METHODS We analyzed the results of treatment of 220 patients with common forms of secondary peritonitis who were treated at the Elizavetinskaya hospital of St. Petersburg in the period from 2013 to 2019. The indicated patients were divided into two groups, comparable in terms of the main features, including the depth pathomorphological changes in the abdominal cavity, assessed by calculating abdominal cavity index (ACI) and the Mannheim peritonitis Index (MPI). The main group consisted of 109 patients, where developed algorithm was used, which supposed planned sanitation relaparotomies within up to 2 days in patients with high values of ACI and MPI. The comparison group included 111 patients who underwent sanitation interventions "on demand", that is, in the presence of signs of persistence of the infectious process in the abdominal cavity. The results of treatment were compared by assessing the level and structure of postoperative mortality, the frequency of complications, and the length of stay in intensive care units and hospital. Mathematical-statistical data processing, calculations of intensive and extensive coefficients of features, assessment of the statistical significance of differences in features for the studied groups were carried out.

RESULTS The use of a differentiated approach to performing planned relaparotomy in patients with generalized peritonitis made it possible to reduce the overall mortality 1.7-fold (from 51.3 to 30.2%) (p=0.001) due to a decrease in the proportion of abdominal sepsis as a cause of unfavorable the outcome. No significant effect of the use of this algorithm on the frequency and structure of complications, as well as the duration of multiple organ failure, was found.

FINDINGS The use of planned relaparotomy among the selected patients helps to reduce postoperative mortality without significantly negatively affecting other treatment results.

Keywords: generalized peritonitis, relaparotomy, laparostomy

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ACI - abdominal cavity index
*C*RP - *C*-reactive protein
GIT - gastrointestinal tract
MPI - Mannheim Peritonitis Index
MOF - Multiple Organ Failure

INTRODUCTION

Despite more than a century history of studying widespread peritonitis, the issues of its treatment remain one of the most difficult problems of abdominal surgery, and the results achieved are far from ideal. Given the multicomponent nature of this disease, the approach to the treatment of patients with widespread peritonitis is multidisciplinary in nature and includes a set of measures aimed at eliminating the source of intra-abdominal infection and correcting homeostasis disorders. Taking into account the successes in the field of anesthesiology and intensive care, the decisive role belongs to the surgical debridement of the septic focus, and the outcome of treatment of this group of patients largely depends on the effectiveness of the latter. Historically, approaches to the surgical treatment of patients with complicated forms of intra-abdominal infection differed from the widespread use of open abdomen techniques at the end of the 19th century to the recognition of relaparotomy as a technical error during the introduction of antibiotic therapy into clinical practice. In the 80s. of XX century a number of works appear on the ineffectiveness in a number of cases of a single surgical intervention for effective sanitation of the abdominal cavity as a reason for the progression of peritonitis, which was the reason for the return of relaparotomy to surgical practice [1]. The currently existing tactics of planned sanitation and relaparotomy “on demand” have a number of known advantages and disadvantages [2–4], which is why the timing and procedure for these interventions are currently not standardized and vary in different medical institutions. Evaluation of the effectiveness of various surgical strategies is also difficult due to some heterogeneity of the compared groups of patients [5].

Objective: to improve the immediate results of treatment of patients with advanced secondary peritonitis by determining approaches to choosing the optimal surgical tactics.

MATERIAL AND METHODS

This work is based on the results of treatment of 220 patients operated on for common forms of secondary peritonitis in the surgical departments of St. Petersburg State Budgetary Healthcare Institution "Elizavetinskaya Hospital" in the period from 2013 to 2019. The study did not include patients with primary and pancreatogenic peritonitis, mesenteric thrombosis with total necrosis of the small intestine, as well as those who died on the first day after admission to the hospital. The patients selected for the study were divided into the following groups:

- the main group, which included 109 patients, in whose treatment with the developed algorithm of planned sanitation relaparotomies was used in accordance with the accepted indications in the period from 2016 to 2019;
- the comparison group of 111 patients, in whose management the strategy of relaparotomy "on demand" was practiced in the period from 2013 to 2015.

The compared groups of patients were comparable in terms of age and gender, the average age was 64.9 ± 18.1 years. The severity of the general somatic background was assessed according to the sum of points on the *APACHE* II scale, calculated upon admission of patients to the intensive care unit for intensive preoperative

preparation. The mean *APACHE* II values did not differ statistically within the groups and amounted to 11.5 ± 7.1 in the comparison group and 11.6 ± 6.5 in the main group (Fig.1).

Fig. 1. The distribution of patients compared according to APACHE II upon admission to intensive care department

The duration of persistence of intra-abdominal infection was assessed from the onset of pain syndrome to the moment of primary surgery; it was 37.9 ± 26.9 and 34.2 ± 27.3 hours in the main and comparison groups, respectively. Upon admission to the hospital after a complex of examinations, all patients underwent standard preoperative preparation, the volume and duration of which was determined by the presence and severity of multiple organ failure (MOF). Intensive therapy was carried out in intensive care units or directly on the operating table in cases where its expected duration did not exceed 2 hours (Fig. 2). Not taking into account 3 patients of the main group and 1 patient of the comparison group who refused surgery within 28 hours from the moment of admission, the average duration of preoperative preparation in the main group was 6.5 ± 8.5 hours, in the comparison group - 4.5 ± 4.9 hours.

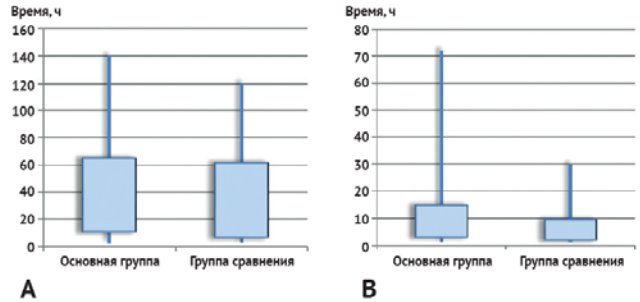

Fig. 2. Terms of performing primary surgical interventions in patients of the compared groups: A — from the onset of the disease to the operation; B — from admission to operations

The structure of diseases that caused generalized intra-abdominal infection is presented in table. 1. Perforated ulcers of various parts of the gastrointestinal tract (GIT) prevailed among the surgical sources of secondary peritonitis – 44 (40.0%) and 55 (49.5%) in the main and comparison groups, respectively. In second place in frequency were tumors of various parts of the gastrointestinal tract, mainly of the colon, complicated by decay and perforation – 28 (25.6%) and 24 (21.6%), respectively. The rather low percentage of complicated forms of acute appendicitis and cholecystitis (7.7% and 4.1%, respectively) is explained by the specifics of surgical departments, among which patients were recruited. Thus, the structure of the main diseases that led to the development of peritonitis among the patients of the compared groups was also comparable.

Table 1

Characteristics of the compared groups according to the source of secondary peritonitis

Primary focus of intra-abdominal infection	Study groups				Total, *n*=220	
	The main group, *n*=109		Comparison group, *n*=111			
	n	%	*n*	%	*n*	%

Gangrenous appendicitis	8	7,3	9	8,1	17	7,7
Gangrenous cholecystitis	6	5,5	3	2,7	9	4,1
Ulcer perforation Chronic duodenal ulcer	26	23,9	34	30,6	60	27,2
Chronic stomach ulcer	7	6,4	13	11,7	20	9,1
Acute stomach ulcer	1	0,9	0	0	1	0,5
Acute small intestine ulcer	9	8,3	5	4,5	14	6,4
Acute colon ulcer	1	0,9	3	2,7	4	1,8
Diverticulum perforation of the colon	4	3,7	6	5,4	10	4,5
Diverticulum perforation of the small intestine	0	0	1	0,9	1	0,5
Tumor necrosis of the colon	22	20,2	19	17,2	41	18,3
Tumor necrosis of the stomach	4	3,7	5	4,5	9	4,1
Tumor necrosis of the gallbladder	1	0,9	0	0	1	0,5
Tumor necrosis of the pancreas	1	0,9	0	0	1	0,5
Tumor necrosis of the prostate	3	2,8	0	0	3	1,4
Tumor necrosis of the uterus	2	1,8	3	2,7	5	2,3
Tumor necrosis of the bladder	0	0	1	0,9	1	0,5
Restrained hernia with necrosis of the small intestine	1	0,9	3	2,7	4	1,8
Mesenteric thrombosis with necrosis of the small intestine	3	2,8	1	0,9	4	1,8
Mesenteric thrombosis with necrosis of the colon	0	0	3	2,7	3	1,4
Traumatic injury of the small intestine	1	0,9	0	0	1	0,5
Traumatic injury of the colon	0	0	2	1,8	2	0,9
Volvulus with necrosis of the small	1	0,9	0	0	1	0,5

intestine						
Volvulus with necrosis of the colon	1	0,9	0	0	1	0,5
Kidney abscess	1	0,9	0	0	1	0,5
Abscesses of the abdominal cavity and retroperitoneal space of unspecified etiology with a breakthrough into the abdominal cavity	4	3,7	0	0	4	1,8
Piosalpinx	2	1,8	0	0	2	0,9

The volume and nature of primary surgical interventions was selected in each case individually and was determined by intraoperative findings, the severity of the patient's condition and the degree of anesthetic risk. In all cases, a median laparotomy was performed as the main surgical access; laparoscopic access was used in 30 patients (27.5%) of the main and 21 patients (18.9%) of the comparison group exclusively for diagnostic purposes – when the fact of the presence of widespread peritonitis was confirmed, the access conversion was carried out. Also, in 3 patients (2.7%) of the main group, laparotomy approaches were supplemented with lumbotomy approaches due to massive contamination of the retroperitoneal space. The volume of surgical interventions performed in most cases was reduced to the elimination of the source of peritonitis with further mechanical debridement and drainage of the abdominal cavity with tubular drains. The installation of tampons was carried out in 1 patient (0.9%) of the main and 2 patients (1.8%) of the comparison group due to signs of diffuse bleeding from disintegrating tumors of various localizations. Information about the operations performed is presented in table 2.

Table 2

Characteristics of primary surgical interventions in patients of the compared groups

Primary surgery	Study groups				Total, *n*=220	
	The main group, *n*=109		Comparison group, *n*=111			
	n	%	*n*	%	*n*	%
Appendectomy	7	6,4	9	8,1	16	7,3
Cholecystectomy	4	3,6	2	1,8	6	2,7
Cholecystectomy with drainage of the biliary tract	2	1,8	1	0,9	3	1,4
Suturing a perforated ulcer Chronic duodenal ulcer	19	17,5	30	27,1	49	22,2
Chronic stomach ulcer	5	4,6	11	9,9	16	7,2
Acute stomach ulcer	1	0,9	0	0	1	0,5
Acute small intestine ulcer	5	4,6	2	1,8	7	3,2
Pyloroplasty	4	3,7	3	2,7	7	3,2
Stomach resection	7	6,4	2	1,8	9	4,1
Colo / enterostomy	5	4,6	7	6,3	12	5,5
Resection of the sigmoid colon	11	10,1	12	10,8	23	10,4
of the small intestine	10	9,2	6	5,4	16	7,2
Hemicolectomy	12	11,0	11	9,9	23	10,5

Suturing of a stomach tumor according to Oppel-Polikarpov	2	1,8	4	3,6	6	2,7
Lancing, draining the abscess of the abdominal cavity	4	3,7	0	0	4	1,8
Adnexectomy	1	0,9	0	0	1	0,5
Other simultaneous interventions	10	9,2	11	9,9	21	9,6

In addition to the direct surgical intervention, the depth of morphological changes in the abdominal cavity was assessed intraoperatively by calculating the abdominal cavity index (ACI) according to V.S. Savelyev and the Mannheim Peritonitis Index (MPI) [6, 7]. Figures 3 and 4 show the results of calculations of these indicators, based on which there was no statistically significant difference in the distribution of patients in the compared groups by the severity of peritonitis: ACI was 14.4 ± 4.2 and 14.2 ± 4.1 in the comparison and main groups, respectively, MPI — 27,4±9,9 и 26,7±10,8.

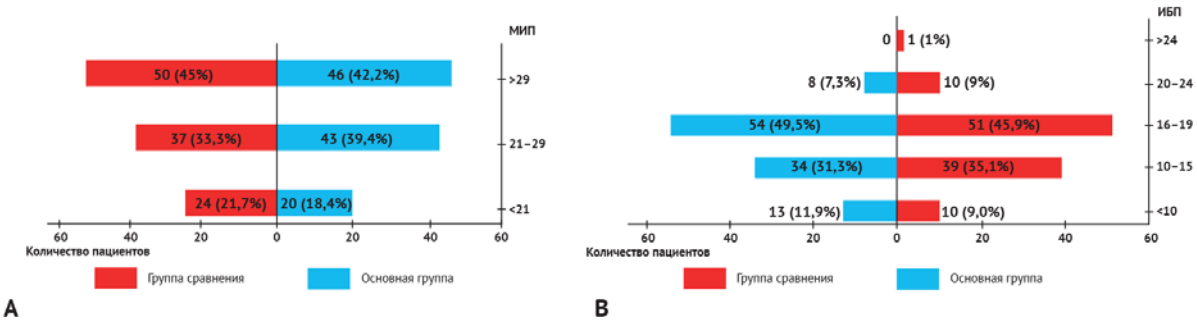

Fig. 3. The distribution of patients in compared groups according to Mannheim Peritonitis Index (A) and the index of the abdominal cavity (B)

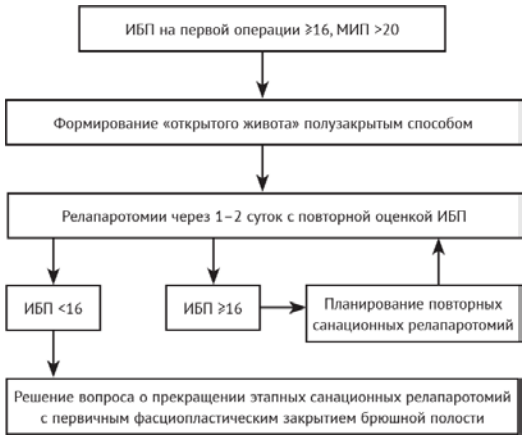

Fig. 4. The surgical tactic for the main group
Notes: ACI — abdominal cavity index (according to V.S. Savelyev); MPI — Mannheim Peritonitis Index

Thus, the groups of patients were comparable in terms of age, sex criteria, general somatic background, volume and nature of surgical interventions performed, as well as the severity of pathomorphological changes in the abdominal cavity. After urgent and emergency surgical interventions, all patients were admitted to intensive care units for intensive and antibiotic therapy according to standard schemes, the same in both compared groups. Further surgical tactics were different: in the comparison group, it was determined by the clinical picture and dynamics of the inflammatory process: signs of tertiary peritonitis served as an indication for relaparotomy along with reasonable suspicions of the development of intra-abdominal complications. In the main group, relaparotomies were planned according to the developed algorithm shown in Fig. 4.

The processing of the research results was carried out by statistical methods, including the calculation of the relative values of frequency and distribution for the studied groups with the determination of statistically

significant differences between them by calculating the *t*-test for independent samples and the χ^2 test for nonparametric tests. The assessment of the normal distribution in the first case was preliminarily calculated by calculating the Kolmogorov-Smirnov test. Differences in the data were considered significant if the *p*-test did not exceed 0.05.

RESULTS AND DISCUSSION

A total of 23 patients (20.7%) in the comparison group underwent repeated interventions, they underwent a total of 35 relaparotomies (on average 1.5±0.7). Of these, in 24 cases, indications for surgery were indirect signs of tertiary peritonitis, in other words, relaparotomies were performed "on demand". When deciding on the need for sanitation intervention, a key role was played by such indicators as the preservation of turbid discharge along the drains, prolonged intestinal paresis, not resolved by conservative measures, and an increase in septic phenomena, assessed by laboratory parameters (levels of leukocytosis, C-reactive protein – CRP) and the level of multiple organ failure. Fig. 5 presents information about the dynamics of these indicators among patients in the comparison group.

Fig. 5. Dynamics of leukocytosis, C-reactive protein (CRP), SOFA score among patients in the comparison group

Based on the data obtained, no significant regularity was found in the levels of leukocytosis and CRP, while the SOFA indices showed a distinct peak on the 4-6th day of the postoperative period. In accordance with the indicated trend and clinical data, the timing of repeated interventions was 3.9 ± 1.9 days. It should be noted that of 24 relaparotomies performed due to the presence of signs of persistence of the inflammatory process in the abdominal cavity, in 11 cases (45.8%) complications were found that did not demonstrate specific manifestations at the preoperative stage - perforated acute ulcers (4 patients), mesenteric thrombosis (4), incompetence of sutures of hollow organs (2), early adhesive intestinal obstruction (1).

In the main group, 40 patients underwent relaparotomy, who underwent a total of 70 repeated interventions (1.75 ± 1.5 on average). According to the developed algorithm, planned relaparotomies were performed in 46 cases (65.7%), the remaining 24 patients (34.3%) were diagnosed with some form of intra-abdominal complications. As a rule, planned relaparotomies were performed in patients with common forms of fecal or purulent peritonitis, with long periods of the disease and pronounced signs of MOF – the objectification of these criteria was carried out by calculating the MPI and ACI. When conducting a retrospective analysis in the comparison group, a positive correlation was found between the values of these indices during the primary surgery and the likelihood of performing relaparotomies in the future (Table. 3).

Table 3

Distribution of ACI and MPI indicators among patients of the compared groups

Patient groups		MPI during the first operation, *n* (%)			ACI during first operation, *n* (%)				
		<21	21–29	>29	<10	10–15	16–19	20–24	>24
Main group	Number of patients (*n*=109)	20 (18,3)	43 (39,4)	46 (42,3)	13 (11,9)	34 (31,3)	54 (49,5)	8 (7,3)	0
	Reoperated (*n*=40)	1 (5)	12 (27,9)	27 (58,7)	1 (7,7)	2 (5,8)	31 (57,4)	6 (75,0)	0
Comparison group	Number of patients (*n*=111)	24 (21,6)	37 (33,3)	50 (45,1)	10 (9,0)	39 (35,1)	51 (45,9)	10 (9,0)	1 (1,0)
	Reoperated (*n*=23)	2 (8,3)	8 (21,6)	13 (26,0)	1 (10,0)	3 (7,7)	14 (27,5)	4 (40)	1 (100)

Notes: ACI — abdominal cavity index (according to V.S. Savelyev); MPI — Mannheim Peritonitis Index

Based on the data obtained, when the ACI value was exceeded by 16 points, the frequency of relaparotomies increased significantly (from 7.7 to 27.5%), while maintaining the indicated trend for higher ACI values. For MPI, a similar value was 21 points, which is why these values were taken as "threshold" values when developing a treatment algorithm that was used in the main group. Making a decision on the need for planned sanitation relaparotomies dictated the need for the formation of a laparostomy in order to facilitate further access to sanitation interventions and prevention of abdominal compartment syndrome. In 34 cases (85%) out of 40, the laparostomy was formed in a half-closed way (covering the internal organs with skin), in 6 patients (15%) – half-open way (implying a complete absence of contact between the tissues of the anterior abdominal wall, isolation of internal organs was carried out with ointment tampons and polyethylene films). The choice of a specific technique for the formation of a laparostomy was determined by the severity of visceral edema and expansion of intestinal loops.

When carrying out relaparotomies, the ACI values were recalculated in order to assess the effectiveness of sanitation measures, and in the main group - to decide on the need for subsequent interventions (Fig. 6). With a decrease in IBP to 15 and below, the question of stopping sanitizing relaparotomies and primary fascioplastic closure of the abdominal cavity was decided. Favorable conditions for the implementation of the last measure were achieved in 26 patients (23.8%) of the main group after one relaparotomy – the abdominal cavity was closed by layer-by-layer suturing of the edges of the surgical wound in 20 cases (76.9%). Another 14 patients needed more than one intervention for adequate sanitation of the abdominal cavity – from 2 to 8. Among these patients, the frequency of primary closure of the laparostomy was significantly lower and amounted to 28.5% (4 patients), which was explained by the lateralization of the abdominal wall against the background of a long absence of contact between aponeurotic edges.

Fig. 6. The values of the index of the abdominal cavity during the time relaparotomies in patients of compared groups

Based on the data obtained, the IBP during relaparotomy in the main group was statistically lower ($p = 0.009$) than in the comparison group (11.5 ± 5.0 versus 14.6 ± 5.5). This fact, as well as the negative dynamics of the *SOFA* indicator in the comparison group, recorded only on the 4-6th day of the postoperative period, may indicate a somewhat untimely performance of relaparotomies "on demand", since changes in laboratory parameters are probably "lagging" in comparison with the progression pathomorphological changes in the abdominal cavity. This tendency served as an argument in favor of a shift in the timing of planned sanitation interventions to earlier time intervals, which amounted to 1.9 ± 0.8 days in the main group (3.9 ± 1.9 – in the comparison group).

The results of treatment were assessed by the frequency and structure of postoperative complications, duration of MOF, stay in intensive care units, bed-day and postoperative mortality. According to the *Clavien-Dindo* classification of surgical complications, an uncomplicated postoperative period occurred in 18 patients (17%) in the main group and in 14 patients (12.6%) in the comparison group. In other cases, various complications were recorded, intra-, extra-abdominal and combined ones. The frequency and structure of the latter did not differ significantly within the compared groups and, as expected, was higher in the subgroups of patients who underwent one or more relaparotomies (Table. 4).

Table 4

The structure of postoperative complications

The severity of postoperative complications *Clavien–Dindo*	Study groups (*n*=220)			
	Comparison group, *n*=111		Main group, *n*=109	
	n	%	*n*	%
Uncomplicated postoperative course	14	12,6	18	17,0
I	10	9,0	12	11,0
II	8	7,2	10	9,1
IIIa	3	2,7	11	10,0
IIIb	8	7,2	14	12,7
IVa	2	1,9	1	0,9
IVb	9	8,1	10	9,1
V	57	51,3	33	30,2

The timing data is summarized in the diagram in Fig. 7. The duration of multiple organ failure, as one of the key links of the septic process, was assessed in accordance with the dynamics of the *SOFA* scale – when its indicators decreased below 2 points, the sepsis phenomena were considered to be stopped. Thus, the duration of sepsis was 5.9 ± 4.5 days in the main and 5.9 ± 4.5 days in the comparison group – no statistical difference was found. At the same time, the average length of stay of patients in intensive care units in the main group was higher: 6.2 ± 8.3 and 17.3 ± 12.2 days versus 11.3 ± 4.7 and 3.0 ± 2.4 days similar indicators in the comparison group. This difference is most likely associated with a higher survival rate in the main group of reoperated patients, whose terms of hospitalization significantly exceeded those for patients who underwent one laparotomy.

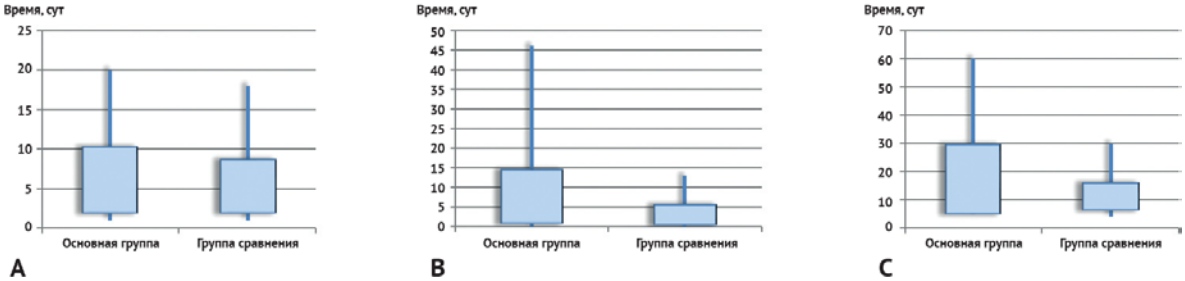

Fig. 7. Duration of multiple organ failure (A), stay in the intensive care units (B), and the average bed-day among the surviving patients (C) of the compared groups

The overall mortality in the main group was statistically lower (p = 0.001) and amounted to 30.2% (33 patients) versus 51.3% (57 patients) in the comparison group (Table 5). The reduction in the relative risk of death was 41%. In the structure of postoperative mortality, there were also differences in the form of a lower proportion of abdominal sepsis as the cause of an unfavorable outcome among patients of the main group (45.5% versus 73.7% in the comparison group).

Table 5

Postoperative mortality structure

Causes of death	Study groups		Total
	Main group, *n*=109	Comparison group, *n*=111	
Pulmonary embolism	4	3	7
Progressive multiple organ failure associated with abdominal sepsis	15	42	57
Mesenteric thrombosis with total necrosis of the small intestine	2	1	3
Bilateral pneumonia	9	8	17
Acute myocardial infarction	1	2	3
Bleeding from acute stomach ulcers	2	1	3
General lethality	33 (30,2%)	57 (51,3%)	90

CONCLUSION

The introduction of planned sanitization relaparotomies into surgical practice and the refusal of reoperations "on demand" contributed to a slight increase in the total number of surgical sanitations performed in the study group, without significantly affecting the average bed-day, the length of stay of patients in intensive care units, the frequency and structure of postoperative complications, as well as the duration of sepsis. However, in the main group, a statistically significant decrease in mortality was achieved, mainly due to a decrease in the role of abdominal sepsis in the structure of unfavorable outcomes. These results are most likely associated with some delay in relaparotomies performed "on demand", since clinically significant indications for such interventions were registered rather late in comparison with the progression of pathomorphological changes in the abdominal cavity. In this regard, the more aggressive surgical tactics of early planned sanitation relaparotomies, based on the initial selection of patients with high values of the abdominal cavity index and the Mannheim index of peritonitis, turned out to be more effective.

The developed treatment algorithm, which implies the construction of surgical tactics for planned sanitation relaparotomies based on an objective assessment of pathomorphological changes in the abdominal cavity in patients with widespread forms of peritonitis, has demonstrated its effectiveness, allowing to reduce the overall postoperative mortality by 1.7 times ($p = 0.001$), which allows us to recommend it for use in clinical practice.

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