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Research Article

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Prevention and Treatment of Intestinal Failure Syndrome in Children with Acute Necrotic Pancreatitis

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AIM OF STUDY To evaluate the effectiveness of intestinal lavage with glucose-saline solution for acute necrotic pancreatitis in children.

MATERIAL AND METHODS A retrospective analysis of the diagnosis and treatment of 48 children aged 3 to 17 years with impaired propulsive function of the intestine against the background of acute necrotic pancreatitis of moderate and severe severity was carried out. Intestinal insufficiency syndrome was diagnosed in 39 cases. In the 1st group (n=13) in I A phase in addition to standard therapy, intestinal lavage was performed during the disease phase, in the 2nd group (n=35) the standard therapy for acute necrotic pancreatitis was performed.

RESULTS Median the duration of gastrostasis in group 1 was 4 days (IQR, interquartile range: 2; 5), in group 2-6 days (IQR: 4; 7) (from 2 to 13), p=0.0181. The duration of intestinal paresis in group 1 was 2 days (IQR: 2; 4), in group 2–4 days (IQR: 3; 5), p<0.0053. The median time of onset of independent stool in group 1 was 3 days (IQR: 3; 5), in group 2 — 5.5 days (IQR: 4.3; 6), p<0.0014. Reduction in the level of C-reactive protein by day 3–4: in group 1, the median was 8.2 mg/l (IQR: 1.16; 34.6) (from 0 to 46.9), in group 2 — 31.97 mg/l (IQR: 17.71; 112.4) (from 14 to 285), p=0.028. The risk of developing purulent complications was 4-fold higher in group 2, p=0.0088. The duration of hospitalization in the 1st group was shorter, p=0.0004.

CONCLUSION Carrying out intestinal lavage in children with impaired propulsive function of the intestine against the background of acute necrotic pancreatitis significantly more quickly restores the function of the gastrointestinal tract and facilitates an earlier start of enteral feeding.

Keywords: children; acute pancreatitis; acute necrotic pancreatitis; parapancreatitis; intestinal insufficiency syndrome; dynamic intestinal obstruction; intestinal lavage

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ANP – acute necrotizing pancreatitis
AP – acute pancreatitis
ALT – alanine aminotransferase
AST – aspartate aminotransferase
CI – confidence interval
CRP-C – reactive protein
DIO – dynamic intestinal obstruction
GIT – gastrointestinal tract
GSS – glucose-salt solution
IFS – intestinal failure syndrome
IQR – interquartile range
MPO – medical and preventive organization
OR – odds ratio
PICU – pediatric intensive care unit
RR – relative risk
SIRS – systemic inflammatory response syndrome

INTRODUCTION

Acute pancreatitis (AP) in children remains one of the complex and pressing problems of pediatric surgery with an incidence rate of 3.6 to 13.2 cases per 100,000 population per year [1]. Despite the fact that the prevalence of AP in the structure of urgent abdominal pathology is only 0.4 to 1.5%, the treatment of this disease is associated with significant financial costs and a long hospital stay. Of greatest clinical interest to surgeons is acute necrotic pancreatitis (ANP), which accounts for up to 20% of all forms of AP [2–4]. The development of severe local and systemic complications in ANP aggravates the severity of the disease with a fatal outcome risk of up to 5%.

Sudden onset, severe abdominal pain localized in the epigastric region with possible spread to the back, increased serum amylase and/or lipase levels (more than 3 times) are the main physiological and clinical laboratory manifestations of AP [3]. With a mild course of AP, against the background of complex therapy, the pathological process is relieved within a few days and does not require surgical intervention. However, the severity of the course of ANP and the formation of risks of a fatal outcome are caused by systemic and organ disorders.

According to the revised Atlanta classification (2012), the course of AP occurs in two phases and has three degrees of severity: mild, moderate, and severe. In mild cases, organ dysfunction and destructive changes in the pancreas do not develop. Moderate severity is characterized by the development of local complications and/or transient organ failure for up to 48 hours. In severe cases, purulent-necrotic parapancreatitis and/or persistent organ failure (lasting more than 48 hours) develop.

The early phase of AP, which usually ends by the end of the first week, is characterized by local inflammation with the formation of necrotic foci in the pancreas or parapancreatic tissue, and endotoxicosis with the development of organ (multiple organ) failure. Progression of the pathological process can lead to generalization of inflammation, which is defined as systemic inflammatory response syndrome (SIRS). With persistent SIRS, the risk of local complications, organ failure, and the likelihood of death increases due to the release of inflammatory mediators.

Many authors in both adult and pediatric practice pay close attention to the role of the intestine in the pathogenesis of septic and organ (multi-organ) complications in urgent abdominal pathology, one of which is AP [5]. The intestine performs not only the function of absorption, digestion, absorption and elimination, but also forms a protective barrier to suppress/absorb pathological agents and harmful substances (toxins, antigens, cytokines) associated with the development of the inflammatory process. Thus, in the pathogenesis and progression of AP, the intestine plays the greatest role, which is actually the "engine" of SIRS and organ failure.

In AP, intestinal motor function is impaired, dysbacteriosis develops with weakened local immunity, hypoperfusion and hypoxemia of the intestinal wall, which leads to apoptosis of enterocytes with the development of a violation of the barrier function of the mucous membrane and entails contamination of opportunistic microflora with the development of uncontrolled translocation of microorganisms and toxins into the bloodstream, abdominal cavity, and there are also pronounced water-electrolyte disturbances, as a result of which the prerequisites for gross violations of homeostasis and the development of SIRS are created [6, 7].

Today, by analogy with the terms that have already entered into widespread practice and characterize organ failure (cardiac, pulmonary, renal, etc.), intestinal failure syndrome (IFS) is separately distinguished. IFS is the main link in the pathogenetic mechanism of the development of complications of acute intestinal failure, in which there is a violation of all intestinal functions (motor, absorption, immune, barrier, etc.). In the development of "intestinal sepsis", SIRS,

endogenous intoxication and multiple organ failure, the next stage is IFS, with the development of which the risk of a fatal outcome increases sharply.

The pathogenesis of IFS is characterized by the development of dynamic intestinal obstruction (DIO), intraintestinal and intra-abdominal hypertension, which lead to disruption of microcirculation in the intestinal wall with the development of trophic disorders in enterocytes and neuroendocrine dysregulation with subsequent increase in intestinal wall permeability [6, 8]. These processes lead to translocation of microflora (usually gram-negative) and the spread of toxemia to the portal bloodstream, lymphatic bed, which leads to infection of the parapancreatic tissue and foci of pancreatic necrosis. In this case, putrefactive and fermentative processes in the intestinal lumen are activated.

DIO, being the leading factor in the development of IFS, is accompanied not only by motor-evacuation disorders of the intestine, failures in microcirculation and increased permeability of the intestinal wall, increasing intra-abdominal pressure due to overstretching of the intestine with gases. It limits the excursion of the diaphragm with a decrease in the respiratory capacity of the lungs and, as a consequence, the development of respiratory failure, pancreatogenic pleurisy with collapse and pulmonary edema.

Considering the significant impact of IFS on the severity of the disease and the condition of patients, prevention and rapid resolution of paralytic ileus are the main tasks in the treatment of this category of patients.

One of the main methods of resolving IFS is intestinal lavage with glucose-salt solution (GSS). Given the isotonicity of the solution, unidirectional massive transport of water through the intestinal wall is excluded. Intestinal lavage reduces intestinal wall edema, restores propulsive function, and promotes partial mechanical removal of opportunistic and pathogenic intestinal microflora, while preserving parietal microflora [9].

The protocol for managing patients with ANP in the first phase of the disease includes nutritional support, which, in case of impaired motor-evacuation function of the intestine, includes parenteral nutrition. Total parenteral nutrition is prescribed in cases of tolerance to enteral nutrition and, given its non-physiological nature, can contribute to more pronounced disorders of intestinal function and the development of a septic process [7].

Thus, intestinal dysfunction in ANP, which is a complex of pathogenetic processes leading to the translocation of microflora and toxins through the intestinal wall with the development of SIRS and septic process, requires timely correction. Early correction of IFS undoubtedly has a positive effect on the severity of the course of ANP and on the condition of sick children in general.

Aim of study: to evaluate the effectiveness of intestinal lavage with glucose-salt solution in acute necrotic pancreatitis in children.

MATERIAL AND METHODS

A retrospective study covering the period from 2005 to 2023 included 48 patients: 10 girls (20.8%) and 38 boys (79.2%). The children's age ranged from 3 to 17 years, with an average of 12 (*IQR*: 7.5; 15) years. All patients were initially hospitalized and treated in health care facilities in the Moscow Region. Due to deterioration of their condition or the need for specialized care, the patients were transferred for further treatment to the M.F. Vladimirsky Moscow Regional Research Clinical Institute (“MONIKI”). All children were admitted to “MONIKI” within 24 hours to 8 days from the onset of the disease.

The diagnosis of ANP was established in the presence of at least two of the three criteria according to the classification developed by the *INSPPIRE group*:

1. Pain in the abdominal area.
2. Increase in the level of amylase and (or) lipase in the blood serum by more than 3 times.
3. Characteristic results of visualization of the gastrointestinal tract on ultrasound of the abdominal cavity and/or CT with contrast enhancement.

Inclusion criteria for the study: age under 18 years, confirmed diagnosis of acute necrotic pancreatitis, IFS, moderate to severe disease course, intestinal paresis, gastrostasis, absence of independent stool for more than 2 days. **Exclusion criteria for the study:** chronic pancreatitis, acute recurrent pancreatitis, intestinal obstruction of obstructive genesis, perforation of a hollow organ, gastrointestinal bleeding, acute appendicitis, hospitalization period from the onset of the disease in MONIKI for more than 8 days and low information content of medical documentation.

The patients were divided into two groups according to the therapy: the 1st group (n = 13) included patients whose complex therapy for acute gastrointestinal tract infections was supplemented by intestinal lavage with GSS; the 2nd group (n = 35) included patients who underwent complex therapy for acute gastrointestinal tract infections without intestinal lavage.

The causes of the development of ANP were the following factors: traumatic in 18 patients (37.5%), biliary in 5 (10.4%), alcoholic in one (2.1%), idiopathic in 22 (45.8%), hypertriglyceridemia in 2 (4.2%).

In the 1st group, 5 patients (10.4%) were operated on in various healthcare institutions of the Moscow region due to the clinical picture of peritonitis before transfer to "MONIKI": one (7.7%) underwent laparoscopy, 4 (30.7%) - laparotomy. In the 2nd group, before transfer to "MONIKI", 3 patients (8.6%) underwent laparoscopy, 26 (54%) - laparotomy.

The main complaints upon admission were: distending pain in 48 (100%), abdominal distension in 48 (100%), lack of stool for 2–3 days in 48 (100%), nausea in 48 (100%), and vomiting in 42 patients (87.5%).

The severity of the course of acute pancreatitis was determined according to the I.I. Dzhanelidze scale of severity of acute pancreatitis and the *SOFA scale* (2 or more points).

The criteria for DIO were: abdominal distension, absence of spontaneous stool, absence of auscultatory peristaltic intestinal sounds, gastrostasis , characteristic sonographic picture in ultrasound (absence of intestinal peristalsis, thickening of the intestinal wall more than 4 mm, pronounced folding of the mucosa, accumulation of fluid and gases in the lumen of the small intestine with expansion of the intestinal diameter more than 30 mm, interloop accumulation of fluid), results of X-ray examination of the abdominal cavity, which persisted for more than 24 hours. If these symptoms resolved within 24 hours, the disease was assessed as DIO.

All children received standard intensive care for acute and chronic obstructive pulmonary disease (COPD) according to diagnostic and treatment protocols; for acute AP, phase I *A* of the disease. In addition to standard treatment, patients in group 1 underwent intestinal lavage using gastrospasm saline on the first day of hospitalization at "MONIKI" [10]. The intestinal lavage technique involved inserting a nasointestinal tube under gastroduodenoscope control at a distance of 20–30 cm from the Treitz ligament, followed by X-ray contrast control of the tube position. After inserting the tube, intestinal lavage was performed using cool gastrospasm saline, which was done as follows: cool hyperosmolar (431.5 mOsm/l) in relation to blood plasma. The presented solution contains equal volumes of 10% glucose and 0.9% physiological sodium chloride solution, administered through an infusion pump on the first day (children aged 5–9 years: volume 200 ml at a rate of 50 ml/hour; children aged 10–14 years: 300 ml at a rate of 100 ml/hour; 15–17 years: 400 ml at a rate of 100 ml/hour). Residual fluid was monitored after 1 hour using active aspiration. All patients also underwent a cleansing enema with a hypertonic solution. On the 2nd day, the volume of the administered solution was increased (children aged 5–9 years: volume 400 ml at a rate of 50 ml/hour; 10–14 years: 600 ml at a rate of 100 ml/hour; 15–18 years: 800 ml at a rate of 100–150 ml/hour). The temperature of the administered fluid was 15–20°C, the assessment was made with an electronic thermometer. In the absence of peristaltic intestinal noises and stool on the 3rd day, the introduction of a cool hyperosmolar solution was continued in the same ranges as on the 2nd day, and a cleansing enema with a hypertonic solution was administered.

The main criteria for resolving IFS and DIO were peristaltic intestinal noises, the presence of independent stool, ultrasound data (reduction in the diameter of intestinal loops to less than 30 mm, effective peristalsis, reduction in intestinal wall edema to less than 4 mm), and the absence of gastrostasis.

Once the DIO resolved, the introduction of GSS into the intestinal tube was stopped, followed by nutritional support with the hydrolyzed Alfare mixture: Day 1: children aged 5–9 years: volume 200 ml at a rate of 40 ml/hour; 10–14 years: 300 ml at a rate of 50 ml/hour; 15–18 years: 400 ml at a rate of 60 ml/hour. If well tolerated (no bloating, presence of stool, decreased enzymatic activity of the blood), isocaloric polymer mixtures were introduced on the 4th–5th day (we used Fresubin Original, Peptamen Junior, Pediashur Maloyezhka, Nutrizon Advanced). In children aged 5–9 years: volume 400 ml, 100 ml/3 hours at a rate of 80 ml/hour; 10–14 years: 600 ml,

100 ml/3 hours at a rate of 100 ml/hour; 15–18 years: 800 ml, 100 ml/3 hours at a rate of 100 ml/hour.

Laboratory and instrumental diagnostics were performed daily for 14 days from the moment of hospitalization of patients, by which time it was possible to either stop destructive processes in the pancreatic parenchyma or prepare for surgical treatment.

Statistical data processing was performed using *GraphPad Prizm v*. 8.0.1 (USA). The Shapiro–Wilk test was used to check the normality of distribution of quantitative indicators. In case of normal data distribution, the indicators were described with the mean value and standard deviation: ($M \pm SD$); with a distribution different from normal, with the median and interquartile range: *Me* (*Q*1– *Q*3). Comparison of two groups by a quantitative indicator, the distribution of which differed from normal, was performed using the Mann–Whitney *U* test. Comparison of percentages in the analysis of contingency tables was performed using the Pearson chi-square test (for values of the expected phenomenon greater than 10), and Fisher's exact test (for values of the expected phenomenon less than 10). In order to assess the relationship between factors represented by quantitative data, the Pearson correlation coefficient was used for a normal distribution, and the Spearman rank correlation coefficient was used for a distribution that differed from normal. The correlation coefficient r_{xy} and ρ , its 95% confidence interval, and the *p value were calculated*.

RESULTS

All children with moderate (*n* = 29) and severe (*n*=19) ANP were hospitalized in the pediatric intensive care unit (PICU). There were no patients with mild ANP in the groups. No statistically significant differences in severity were noted in the comparison groups. Comparison of the groups by severity of necrotic pancreatitis on admission is presented in Table 1.

All patients (*n* = 48) had DIO upon admission to the hospital. Ileus (absence of intestinal sounds), gastrostasis and absence of independent stool were detected in 48 patients (100%). Signs of ileus based on the results of ultrasound and abdominal X-ray were also detected in 48 patients. (100%). Comparison of groups by various parameters upon admission to the DRO is presented in Table 2.

Table 1

Assessment of the severity of acute necrotizing pancreatitis on admission

Criteria		Group 1 (*n* = 13)	Group 2 (*n* =35)
SOFA Me (*IQR*)		4 (3; 5)	3 (3; 3)
Acute pancreatitis severity scale, abs. (%)	mild (1 point)	0	0
	moderate (2-4 points)	8 (16.6)	21 (43.7)
	Severe (5 points or more)	5 (10.4)	14 (29.1)

Notes: *IQR* — interquartile range scope; *SOFA - Sequential Organ Failure Assessment*

Table 2

Main characteristics of patients in the selected groups upon admission

Indicator, level		Group 1 (*n* = 13)	Group 2 (*n* =35)
Age, years, *Me* (*IQR*)		15 (8; 16)	12 (8; 14)
Gender, abs. (%)	boys girls	4 (8.3) 9 (18.7)	13 (27) 22 (45.8)
Leukocytes, ×10 ^{9} /l, *Me* (*IQR*)		14 (10.8; 19.0)	9.7 (7.9; 13.6)
Neutrophils, %, *Me* (*IQR*)		84.3 (81.7; 85.4)	74.9 (49.9; 81.7)
With RB, mg/l, *Me* (*IQR*)		94.9 (56; 107)	104.5 (67.5; 167)
Blood amylase, U/L, *Me* (*IQR*)		1044 (286; 1758)	300 (158.5; 405.5)
Urine amylase, U/L, *Me* (*IQR*)		2675 (1698; 4006)	1695 (686; 2350)
Lipase, U/l, *Me* (*IQR*)		503 (461; 545)	424 (265; 767)
Total bilirubin, μmol/l, *Me* (*IQR*)		11.6 (8.8; 23.5)	10 (7; 12)
ALT, U/L, *Me* (*IQR*)		21.5 (17; 31)	25.1 (17; 38)
AST, U/L, *Me* (*IQR*)		37 (27.5; 55.5)	47.5 (31.3; 63)
Creatinine, μmol/l, *Me* (*IQR*)		58.5 (46; 80.5)	60 (42.5; 69)
Urea, mmol/l, *Me* (*IQR*)		4 (3.5; 5.8)	4.5 (3.3; 7.2)
Parapancreatitis, abs. (%)	*A* *B* *WITH* *D* *E*	0 2 (4.2) 5 (10.4) 2 (4.2) 4 (8.3)	1 (2) 6 (12.5) 11 (22.9) 11 (22.9) 6 (12.5)

Notes: *CRP* - C-reactive protein; ALT – alanine aminotransferase; AST – aspartate aminotransferase; *IQR* - interquartile range

The development of IFS was statistically significantly more common in patients admitted to our hospital who underwent a sanitation and drainage operation via laparotomy, *p* = 0.0205 (Fig. 1).

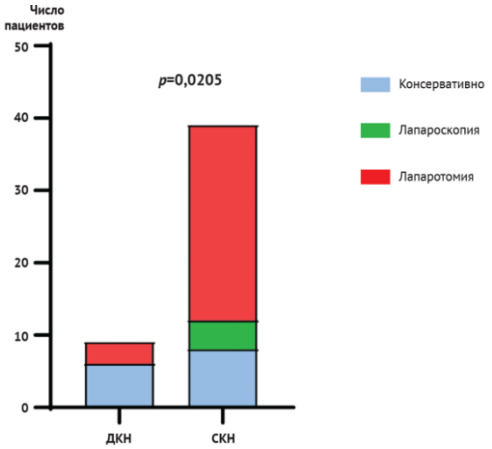

Fig. 1. Distribution of patients with dynamic intestinal obstruction (DIO) and intestinal failure syndrome (IFS) depending on treatment tactics in medical and preventive organizations of the Moscow region

In a retrospective analysis, it was found that the risk of developing IFS was higher in the group where intestinal lavage was not performed: relative risk (*RR*) = 1.69, 95% confidence interval (*CI*) [1.15; 3.15], ratio odds (*OR*)=9.14 95% *CI* [1.93; 37.41], *p* =0.0073 (Fig. 2).

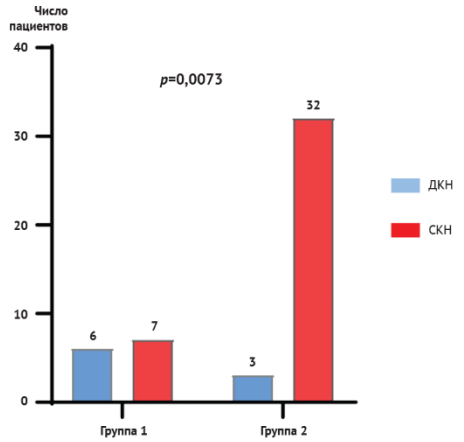

Fig. 2. Distribution of patients with dynamic intestinal obstruction (DKO) and intestinal failure syndrome (SFO) in groups depending on the intestinal lavage procedure

Relief of intestinal paresis (within the first 24 hours) and gastrostasis (within the first 48 hours) was observed in 6 patients (12.5%) in group 1 and in 3 patients (6.3%) in group 2. Clinical manifestations of IFS were detected in 7 patients (14.6%) in group 1 and in 32 patients (66.6%) in group 2. During intestinal lavage, the time of IFS resolution was significantly shorter than in the comparison group. The median duration of gastrostasis in group 1 was 4 days (*IQR*: 2; 5) (from 2 to 6), in group 2 — 6 days (*IQR*: 4; 7) (from 2 to 13), *p* = 0.0181, statistically significant (Fig. 3A*)*. The duration of ileus in group 1 was 2 days (*IQR*: 2; 4) (from 2 to 4), in group 2 the median was 4 days (*IQR*: 3; 5) (from 2 to 6), *p* <0.0053, statistically significant (Fig. 3B*)*. The median time to independent stool in group 1 was 3 days (*IQR*: 3; 5) (from 2 to 5), in group 2 it was 5.5 days (*IQR*: 4.3; 6) (from 3 to 10), *p* <0.0014, statistically significant (Fig. 3C*)*. Statistically significant direct correlations were also established between the duration of hospitalization and the duration of ileus (ρ = 0.343 [95% *CI* : 0.06; 0.57], p = 0.017; with the duration of gastrostasis (r_{xy} = 0.508 [95% *CI* : 0.3; 0.7], *p* = 0.0002); and the duration of independent stool (ρ = 0.311 [95% *CI* : 0.03; 0.5], *p* = 0.031).

Enteral feeding *per os* in group 1 was started on the 7th day (*IQR*: 6; 9) (from 5 to 10), in group 2 the median was 11 (*IQR*: 7.3; 14.8) (from 3 to 29) , *p* = 0.0512.

It is worth noting that in group 1, after intestinal lavage, on the 2nd–3rd day, a hydrolyzed mixture was introduced into the nasointestinal tube with a gradual transition to the introduction of isocaloric polymer mixtures (we used Fresubin original, Peptamen junior), and group 2 was given parenteral nutrition due to long-term tolerance to enteral nutrition.

When assessing the level of C -reactive protein upon admission, no statistically significant differences were noted; in the 1st group, the median was 34.54 mg/l (IQR: 26.36; 118.0) (from 3.45 to 127), in the 2nd group 16 mg/l (IQR: 6.54; 31) (from 3 to 285), p = 0.119. On the 3rd–4th day after hospitalization, a significant decrease in the level of C- reactive protein was noted in group 1, the median was 8.2 mg/l (IQR: 1.16; 34.6) (from 0 to 46.9), in group 2 — 31.97 mg/l (IQR: 17.71; 112.4) (from 14 to 285), p = 0.028, statistically significant. No statistically significant differences in the level of leukocytes were noted over time.

The risk of developing purulent complications was 4 times higher in group 2: *RR* = 3.9 95% *CI* [1.34; 14.16], *OR* = 8.2, 95% *CI* [1.68; 40.03], *p* = 0.0088.

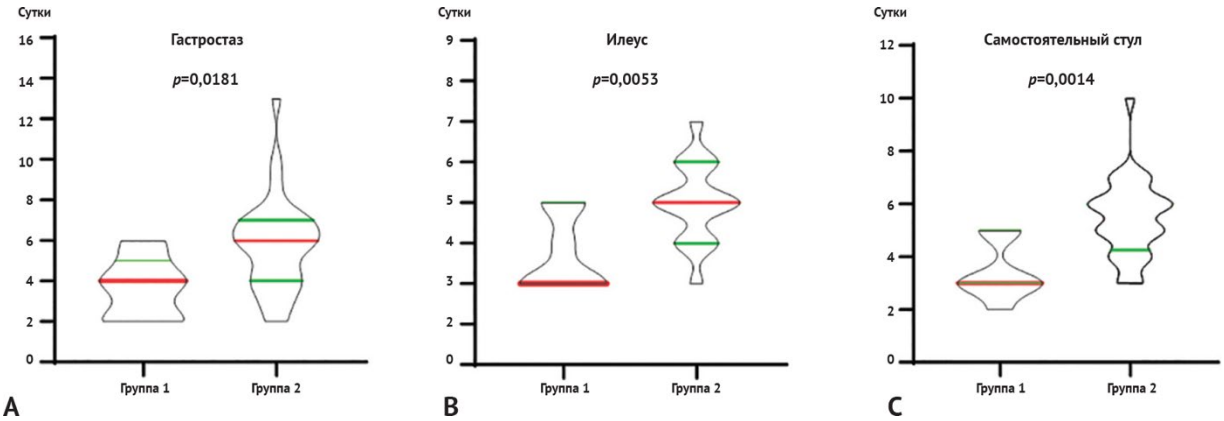

Fig. 3. A — duration of gastrostasis in comparison groups. B — duration of ileus in comparison groups. C — time of independent stool in comparison groups

Notes: Mann–Whitney test. Medians, first and third quartiles are given, the shape of the figures reflects the distribution of the feature

A total of 33 late complications developed: 5 in group 1 and 28 in group 2. The risk of complications was 2 times higher in the group without intestinal lavage: *RR* = 2.08, 95% *CI* [1.185; 4.581], *OR* = 6.4, 95% *CI* [1.539; 27.07], *p* = 0.0120. Recovery occurred in 15 cases (8 in group 1 and 7 in group 2), external pancreatic fistula developed in 20 cases (1 in group 1 and 19 in group 2), and pseudocyst developed in 13 cases (4 in group 1 and 9 in group 2), *p* = 0.0059, statistically significant.

There were no indications for relaparotomy in the 1st group; in the 2nd group, 8 patients (16.6%) were re-operated using laparotomy access.

The median duration of hospitalization in the 1st group was 20 days (*IQR*: 15.5; 36.5) (from 10 to 55), in the 2nd group - 39 (*IQR*: 34; 54) (from 25 to 101), *p* = 0.0004, statistically significant (Fig. 4).

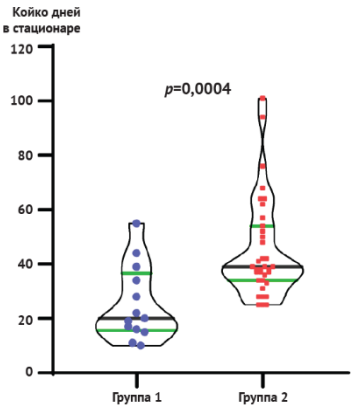

Fig. 4. Duration of hospitalization in the study groups

Notes: Mann–Whitney test. Medians, first and third quartiles are given, the shape of the figures reflects the distribution of the feature

DISCUSSION

Despite the large number of publications and developed methods, the problem of treating children with acute inflammation of the pancreas remains relevant. Taking into account such factors as the duration of hospitalization from the onset of the disease and the etiopathogenesis of the inflammatory process in the pancreas, an individual approach to the treatment of patients with ANP is necessary. Standardization of the approach to diagnosis and treatment (conservative and surgical), which has been developed for years, does not lead to significant success in treating this category of patients [11]. In some cases, there is an underestimation or overestimation of the severity of the patients' condition, which leads to the development of formidable complications and repeated operations [12]. Most patients admitted from MPO of the Moscow Region underwent laparotomy with opening and drainage of the omental bursa, which in some cases was inappropriate and contributed to the deterioration of the general condition of patients, a decrease in the propulsive function of the intestine, infection of the inflammatory process in the pancreas and parapancreatic tissue, as well as the development of IFS. The reason for the operation was the symptoms of peritonitis and a picture of intestinal obstruction.

Disorders of the propulsive function of the intestine in the form of DIO and gastrostasis are among the main reactions of the body to damage or inflammation of the pancreas, leading to the development of IFS. In most cases, complex therapy

was carried out without taking into account and correcting IFS.

In adult practice, there are many publications and meta-analyses proving that ANP is the main factor in the development of complications and fatal outcomes in patients with ANP [11, 12]. Unfortunately, there are practically no publications devoted to acute necrotic pancreatitis in children, either in domestic or foreign literature. The assessments of ANP and methods for its diagnosis developed in adult practice are not always applicable and difficult to apply in children. We did not assess intra-abdominal hypertension, which also affects the severity of the condition and the outcome of treatment in children with ANP, in our study, since most of the children had undergone surgery before being transferred to our hospital.

The mechanism of IFS in AP has not been sufficiently studied, but dysfunction of the intestinal barrier is considered the main pathognomonic mechanism for the development of this process [13, 14]. In phase I *A* of the disease, hypovolemia and fluid sequestration in the third space and visceral vasoconstriction lead to intestinal hypoperfusion. This leads to reperfusion, which in turn leads to ischemia-reperfusion injury. The resulting vicious circle of hypoperfusion and damage to the gastrointestinal tract (GIT) disrupts the intestinal barrier [15]. Dysfunction of the intestinal barrier promotes the translocation of opportunistic microflora and endotoxins into the portal bloodstream and lymphatic system. The end result of this pathological process is SIRS, infection of pancreatic necrosis foci and the development of organ (multiple organ) failure [16]. In addition, with ANP, in addition to the barrier function of the gastrointestinal tract, the endocrine, immune, digestive and absorption functions are affected [17].

Taking into account the developing pathological processes and dysfunctions, one of the main tasks in the I *A* phase of the disease is the prevention and early correction of the gastrointestinal tract. The results of our retrospective analysis demonstrate the effectiveness of intestinal lavage with GSS, which facilitates the onset of early enteral nutrition and the prevention of damage to the gastrointestinal mucosa.

The use of intestinal lavage in phase I *A* of the disease of acute intestinal obstruction with the aim of restoring the propulsive function of the gastrointestinal tract allowed to reduce the number of surgical interventions, statistically significantly reduce the frequency of open surgical interventions (in the 1st group - 4 patients, in the 2nd group - 31 patients), $p = 0.0001$; when performing intestinal lavage, to reduce the duration of gastrostasis to 2 days and intestinal paresis to 3 days. Early restoration of propulsive function of the intestine with the relief of IFS after intestinal lavage allowed to reduce the incidence of purulent complications.

Early restoration of gastrointestinal function contributed to a decrease in SIRS (the level of *C* - reactive protein by the 3rd–4th day of hospitalization significantly decreased), which is another argument for performing intestinal lavage in the early stages of the inflammatory process in the pancreas.

The small number of observations and the experience of one center with the aim of improving the quality of treatment of children with ANP and reducing the incidence of complications dictate the need for a multicenter prospective study aimed at studying ANP in children.

CONCLUSION

The presented study established and statistically substantiated the facts of faster recovery of the gastrointestinal tract function when performing intestinal lavage with glucose-salt solution, which helps to reduce the frequency of complications and the duration of hospitalization of children with acute necrotic pancreatitis. Intestinal failure syndrome in children with necrotic pancreatitis is one of the main factors in the development of systemic inflammatory response syndrome and multiple organ failure. Early start of enteral nutrition in a nasointestinal tube prevents the development of hypermetabolic catabolism syndrome, helps to restore the trophic status and speedy recovery of sick children.

1. The use of intestinal lavage with glucose-salt solution in children with acute necrotic pancreatitis in patients of group 1 promotes early restoration of propulsive function of the intestine and reduces the risk of developing purulent complications by 4 times compared to patients of group 2 ($RR = 3.9$, 95% *CI*: [1.34; 14.16], $OR = 8.2$, 95% *CI*: [1.68; 40.03], $p = 0.0088$), which reduces the frequency of open surgeries ($p = 0.0001$).

2. The use of the developed method in the complex treatment of children with necrotic pancreatitis allows to reduce the duration of inpatient treatment by 2 times (1st group - 20 days (*IQR*: 15.5; 36.5) (from 10 to 55), 2nd group - 39 (*IQR*: 34; 54) (from 25 to 101), p = 0.0004), which significantly reduces the economic costs of treating this category of patients.

REFERENCES

1. Tian G, Zhu L, Chen S, Zhao Q, Jiang T. Etiology, case fatality, recurrence, and severity in pediatric acute pancreatitis: a meta-analysis of 48 studies. *Pediatric Res* . 2022;91(1):56–63. PMID: 33742133 https://doi.org/10.1038/s41390-021-01454-1
2. Abu-El-Haija M, Kumar S, Quiros JA, Balakrishnan K, Barth B, Bitton S, et al. Management of Acute Pancreatitis in the Pediatric Population: A Clinical Report from the North American Society for Pediatric Gastroenterology, Hepatology and Nutrition Pancreas Committee. *J Pediatr Gastroenterol Nutr* . 2018;66(1):159–176. PMID: 29280782 https://doi.org/10.1097/MPG.0000000000001715
3. Uc A, Husain SZ. Pancreatitis in Children. *Gastroenterology* . 2019;156(7):1969–1978. PMID: 30716320 https://doi.org/10.1053/j.gastro.2018.12.043
4. Pyhteev DA, Bokova TA, Elin LM, Mikhaleva OG. Pancreonecrosis as a complication of biliary pancreatitis in a child with morbid obesity. *Experimental and Clinical Gastroenterology.* 2023;(7):162–169. (In Russ.) https://doi.org/10.31146/1682-8658-ecg-215-7-162-169
5. Pagliari D, Rinninella E, Cianci R, Attili F, Franza L, Luciano R, et al. Early oral vs parenteral nutrition in acute pancreatitis: a retrospective analysis of clinical outcomes and hospital costs from a tertiary care referral center. *Intern Emerg Med* . 2020;15(4):613–619. PMID: 31620978 https://doi.org/10.1007/s11739-019-02210-4
6. Ivanova GYe, Popova TS, Shestopalov AE, Tropskaya NS, Matkevich VA, Vladimirova ES, et al. New Approaches to Complex Treatment of the Syndrome of Intestinal Insufficiency as Animportant Component of Post-Aggressive Rehabilitation of Surgical Patients Incritical Condition. *Bulletin of Rehabilitation Medicine* . 2018;86(4):42–53. (In Russ.)
7. Ponomarev SV, Sorokin EP, Leyderman IN, Shilyaeva EV. Influence of Intestinal Failure Syndrome on the Clinical Course of Traumatic Disease in Patients With Thoracic and Abdominal Trauma. *Polytrauma* . 2020;(2):21–28. (In Russ.) https://doi.org/10.24411/1819-1495-2020-10016
8. Kiselev VV, Petrikov SS, Zhigalova MS, Novikov SV, Shavrina NV, Yartsev PA. Restoration of Intestinal Propulsion in Patients with Severe Acute Pancreatitis in the Conditions of the Resuscitation and Intensive Care Unit. *Russian Sklifosovsky Journal "Emergency Medical Care".* 2023;12(2):210–216. https://doi.org/10.23934/2223-9022-2023-12-2-210-216
9. Bykov MV, Lazarev VV, Ploskireva AA. The Use of Intestinal Lavage in Children in the Intensive Care Unit. *The Russian Archives of Internal Medicine.* 2017;7(2):152–157. (In Russ.) https://doi.org/10.20514/2226-6704-2017-7-2-152-157
10. Pykhteev DA, Elin LM, Sokolov YuYu, Bokova TA. Patent RF No 2806123 C1. MPK 51. A61M 25/01 (2023.02); A61K 33/14 (2023.02); A61K 31/7004 (2023.02); A61K 38/43 (2023.02); A61K 47/42 (2023.02); A61K 9/08 (2023.02); A61P 1/00 (2023.02); A61P 1/18 (2023.02). *Method for the comprehensive treatment of dynamic intestinal obstruction in children with acute pancreatitis.* No. 2022127995; decl. 28.10.2022; publ. 26.10.2023. Bull. No. 30. (In Russ.) Available at: https://patentimages.storage.googleapis. com/90/0d/e3/cc46ab8fd9e5dc/RU2806123C1.pdf (Accessed Nov 26, 2024)
11. Minnullin MM, Zefirov RA, Shavaliev RF, Akhundov RN, Bayalieva AZh, Gardanov ShD. Features of salt enteral solution application in the treatment of various forms of acute pancreatitis. Wounds and Wound Infections. *The Prof. BM Kostyuchenok Journal.* 2020;7(1):58–66. (In Russ.) https://doi.org/10.25199/2408-9613-2020-7-1-58-66
12. Paulino J, Ramos G, Gomes FV. Together We Stand, Divided We Fall: A Multidisciplinary Approach in Complicated Acute Pancreatitis. *J Clin Med.* 2019;8(10):1607. PMID: 31623392 https://doi.org/10.3390/jcm8101607
13. Hu B, Sun R, Wu A, Ni Y, Liu J, Guo F, et al. Severity of acute gastrointestinal injury grade is a predictor of all-cause mortality in critically ill patients: a multicenter, prospective, observational study. *Crit Care.* 2017;21(1):188. PMID: 28709443 https://doi.org/10.1186/s13054-017-1780-4
14. Reintam Blaser A, Poeze M, Malbrain ML, Björck M, Oudemans-van Straaten HM, Starkopf J; Gastro-Intestinal Failure Trial Group. Gastrointestinal symptoms during the first week of intensive care are associated with poor outcome: a prospective multicentre study. *Intensive Care Med* . 2013;39(5):899–909. PMID: 23370829 https://doi.org/10.1007/s00134-013-2831-1
15. Chen F, Liu Y, Shi Y, Zhang J, Liu X, Liu Z, et al. The emerging role of neutrophilic extracellular traps in intestinal disease. *Gut Pathog* . 2022;14(1):27. PMID: 35733158 https://doi.org/10.1186/s13099-022-00497-x
16. Magnan C, Lancry T, Salipante F, Trusson R, Dunyach-Remy C, Roger C, et al. Role of gut microbiota and bacterial translocation in acute intestinal injury and mortality in patients admitted in ICU for septic shock. *Front Cell Infect Microbiol* . 2023;13:1330900. PMID: 38179421 https://doi.org/10.1097/MCG.0b013e3182652096 eCollection 2023.
17. Bykov MV, Prometneu DV, Mayorov AD, Mutsilkhanova MM, Tyaglecova LN, Fedyushkina VO, et al. Oxygenated Salt Enteral Solution in the Treatment of a Child With Pancronecrosis. *Russian Journal of Pediatric Surgery, Anesthesia and Intensive Care* . 2020;10(2):209–216. (In Russ.) https://doi.org/10.17816/psaic673

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