ORIGINAL ARTICLE

CONTENTS

Intra-abdominal hypertension and pancreatic destruction in patients with acute necrotizing pancreatitis

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ABSTRACT

Aim: To determine the relationship between intra-abdominal hypertension and the volume of pancreatogenic necrosis in patients with acute necrotizing pancreatitis.

Materials and Methods: A prospective single-center study of 32 adults with acute necrotizing pancreatitis (ANP). A correlation was made between the maximum intra-abdominal pressure (IAP) in the early phase of the disease and the area of pancreatic necrosis and extrapancreatic necrosis (EPN) according to CT data. A one-factor linear regression model was built, based on the linear dependence of the volume of EPN on the maximum value of IAP.

Results: A positive correlation between the IAP level and the volume of EPN was revealed, $\rho = 0.547$ ($p=0.0012$). No linear correlation between the level of IAP and the degree of necrosis of the pancreas ($p=0.368$). The volume of EPN was related to the indicator of IAP($p<0.001$). When the IAP level increases for each mm Hg., the volume of EPN increased, on average by 146.29 ± 37.74 ml ($p<0.001$).

Conclusions: The increase in IAP in the early phase of ANP was accompanied by an increase in the volume of EPN, $\rho = 0.547$ ($p=0.0012$). In the study it was possible to predict EPN volume by measuring the level of IAP in the early phase of the disease with an 15.02 ml error. An increased IAP can be considered one of the markers of an increase in the volume of EPN in patients with ANP.

KEY WORDS: acute pancreatitis, intraabdominal pressure, pancreatic necrosis, extrapancreatic necrosis

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INTRODUCTION

Necrotic pancreatitis occurs with a frequency of 20% among diagnosed cases of acute pancreatitis with mortality rate of 20-40% depending on the volume of the necrotic lesion [1-2]. The duration of early organ failure caused by the systemic inflammatory response determines the severity of acute pancreatitis and predicts mortality [3-7]. Pancreatogenic necrosis with associated infection, in turn, determines organ failure in the second phase of the disease and increases mortality in these patients to 30-65% [8-11].

A persistent increase in intra-abdominal pressure (IAP) is a proven predictor of the severity of acute pancreatitis: microcirculation disorders associated with cytokine storm and organ failure and intra-abdominal hypertension (IAH) create a vicious circle, which is another challenge in the complex of intensive care of acute severe pancreatitis [12-13]. Systemic inflammatory response syndrome, increased capillary permeability, swelling of retroperitoneal tissue, functional intestinal obstruction, decreased compliance of abdominal wall lead to mechanical compression of vessels, cellular hypoxia, organ ischemia, increased interstitial edema, and increased IAP [14-16]. The effect of increased abdominal pressure on the organs of the abdominal cavity and retroperitoneal space with subsequent laboratory-clinical manifestation of multiple organ failure is described in experimental works related to induction of abdominal compartment syndrome in laboratory animals [17-19]. Hepatic, venous, arterial and microcirculatory blood flow significantly decreases with even a slight increase in IAP [20-21]. Necrosis of the pancreas and extrapancreatic tissue in the manifestation of acute pancreatitis, which is pathophysiologically caused by premature activation of pancreatic enzymes, may also depend on circulatory changes in IAH syndrome.

AIM

The aim of the study was to determine the relationship between intra-abdominal hypertension and the volume of pancreatic and extrapancreatic necrosis in patients with acute necrotizing pancreatitis.

Table 1. Data presentation

Indicator	Median	QI-QIII
Intra-abdominal pressure, max, mm Hg	15	13-16
Volume of extrapancreatic necrosis, ml	1790	1590-2025
Pancreatic necrosis area, ranks	**Absolute value**	**Percentage, CI% (confidence interval)**
I (<30%)	1	3.1 (1 - 16.2)
II (30-50%)	2	6.2 (0.8-20.8)
III (>50%)	29	90 (75-98)

Table 2. Coefficients of a one-factor model for predicting the volume of extrapancreatic necrosis in patients with acute necrotizing pancreatitis

Indicator	Value of model coefficient b±m(b)	Significance level of the coefficient difference from 0, p
Const	-257.79±551.32	p=0.64
X1	146.29±37.74	p=0.0005

MATERIALS AND METHODS

The study was a prospective cross-sectional non-randomized single-center study of 32 adult patients with acute necrotizing pancreatitis (ANP) treated in 2023 at the Department of General Surgery No. 1 of the Bogomolets National Medical University. Of the patients, 56% (18/32) were male, 44% (14/32) were female, with an average age of 49±3 years. The study included patients with acute pancreatitis, confirmed in compliance with the 2012 revised criteria of Atlanta [5], having signs of transient or persistent organ failure. The patients underwent computed tomography of abdominal cavity and retroperitoneal space with intravenous contrast in the second week after the onset of the disease with pancreatic necrosis confirmed by calculating the pancreatic necrosis index (PNI) and measuring the volume of extrapancreatic necrosis (EPN) in millilitres. Exclusion criteria: acute mild pancreatitis, absolute contraindications to performing computed tomography, death in the first week of the disease, patients with neurogenic bladder disease, which made it impossible to measure IAP.

IAP monitoring was carried out in the studied patients in the early phase of the disease. For further calculations, the maximum indicator among those measured ones was selected. An indirect method was chosen to measure IAP: 100 ml of sterile physiological solution was slowly injected into the lumen of an empty bladder using a Foley catheter and a drip system. After that, the intravesical pressure was measured using a ruler in mm H2O, whereas the level of the pubic symphysis was taken as zero. The obtained results were translated into mm Hg: 1 mm Hg. = 13.5951 mm H2O [22].

The first step was to determine the relationship between the maximum value of IAP, mm Hg, the volume of EPN in millilitres, and the degree of pancreas necrosis, which was ranked depending on the percentage of lesions according to PNI (I-<30%, II- 30 - 50%, III- > 50%) Spearman's rank correlation index ρ was calculated after checking the distribution of values for normality.

The second step included the construction and analysis of a univariate linear regression model. The analysis was based on the linear dependence of the resulting feature Y (volume of extrapancreatic lesion, EPN) on the factor feature X1 (maximum value of IAP in the early phase of the disease, IAP). The value of the model coefficient, b±standard error m(b), adjusted coefficient of determination R^2adj, F value, root mean square error RSE were calculated. A value of $p<0.05$ was considered statistically significant. The EZR (R-statistics) package was used for data calculation and analysis [23].

RESULTS

The median (QI-QIII) of the maximum IAP among the patients was 15 (13-16) mmHg, the median volume of EPN was 1790 (1590-2025) ml, respectively. Pancreatic necrosis of more than 50% was recorded in 90% (CI% 75-98) of patients. The distribution of ICP values and EPN volume differed from normal, $p<0.05$. (Table 1)

The first thing to be determined was a relationship between the level of IAP in the early phase of the disease and the volume of EPN. For this purpose, Spearman's rank correlation index was calculated. The value of the correlation coefficient $\rho = 0.547$ (statistically significantly different from 0, p=0.0012). Consequently, the existence of a positive correlation between the level of IAP and the volume of EPN was revealed. An increase in IAP in the early phase of ANP disease was on average accompanied by an increase in the volume of EPN (Fig. 1).

Another thing to find out was the relationship be-

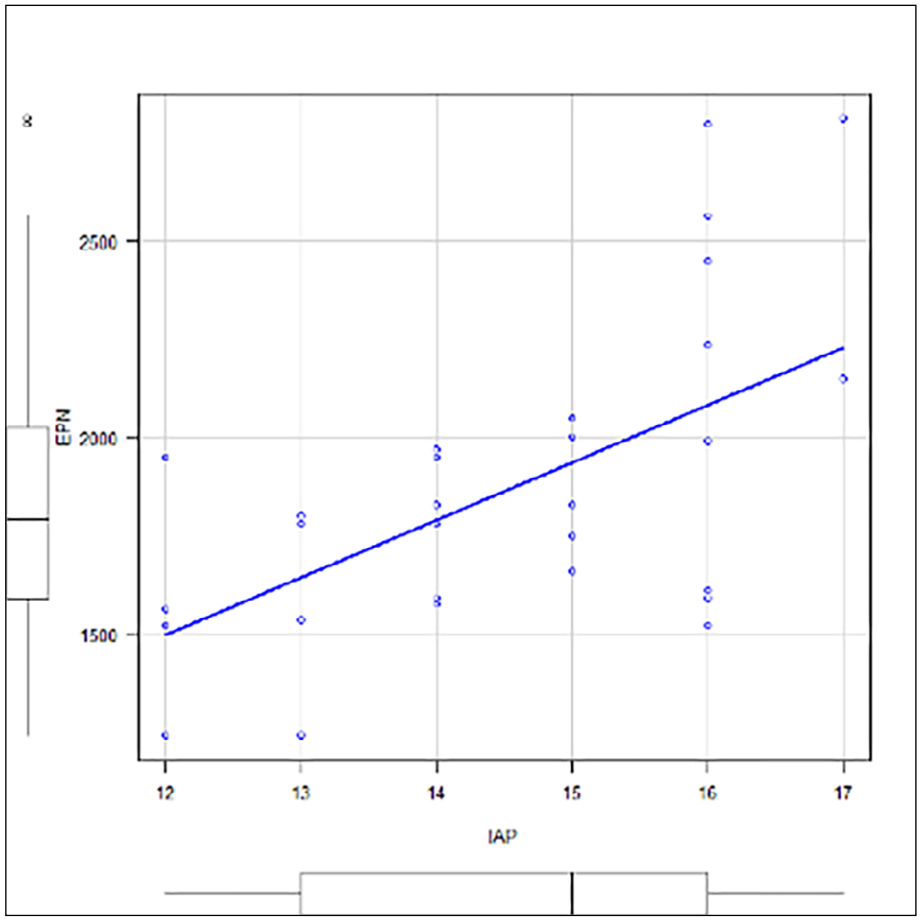

Fig. 1. Correlation field of intraabdominal pressure (IAP) mm Hg, and the volume of extrapancreatic necrosis (EPN) ml, $p<0.001$.

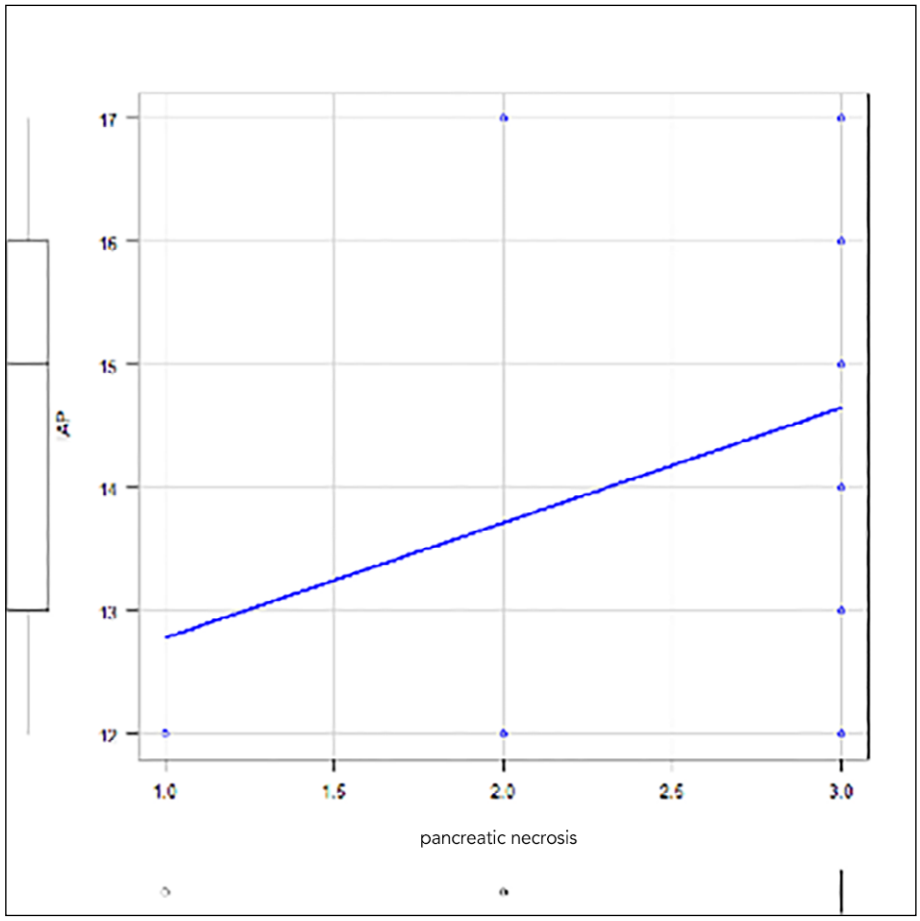

Fig. 2. Correlation field of intraabdominal pressure (IAP), mm Hg, and pancreatic necrosis area, ml, $p<0.001$.

tween the level of IAP in the early phase of the disease and the area of pancreas necrosis in accordance to three ranks. For this purpose, Spearman's rank correlation index was calculated. The value of the correlation coefficient ρ = 0.165 was not statistically significantly different from 0 (p=0.368). Thus, a linear correlation between the level of IAP and the degree of necrosis of the pancreas was not detected (p>0.05) (Fig. 2)

The method of building and analyzing a one-factor linear regression model was used for further analysis of the EPN volume dependence on the IAP indicator in the early phase of the disease, estimated in mmHg, Dependence of the initial variable (the volume of extrapancreatic necrosis) on the IAP value was revealed. Adjusted coefficient of determination R^2adj = 0.3115, F value 15.02, p<0.001, root mean square error RSE = 320.2 (with 30 degrees of freedom). Table 2 shows the results of estimating model coefficients.

Thus, it was established that the volume of EPN in patients with ANP is related (p<0.001) to the indicator of IAP in the early phase of the disease. When the IAP level increases for each mm Hg., the volume of EPN increased on average by 146.29±37.74 ml (p<0.001). The obtained mathematical model for forecasting the volume of the EPN can be expressed by the formula:

Y=(-257.79) + 146.29×X1

Formula X1 - IAP in the early phase of the disease, Y - volume of extrapancreatic necrosis

DISCUSSION

The area of pancreatic destruction is determined in order to choose treatment tactics, just as well as for the purpose of the expected disease results, i.e. patient's stay in hospital, frequency of complications and risk of organ failure development [24-26].

The classic CT index of acute pancreatitis severity, which among other things evaluates in percentage the area of pancreas parenchyma damage [27], is now increasingly frequently supplemented by the calculation of extrapancreatic damage volume [28-30], which also applies to the early phase of the disease [31].

Pancreatogenic necrosis infection significantly worsens the disease prognosis [32-33], the volume of the lesion correlates with the severity of septic complications. High IAP increases the risk of hypoperfusion and translocation of intestinal microflora to lesions. Earlier, we also considered the derivative of intra-abdominal pressure - abdominal perfusion pressure as a predictor of infection duration in patients with ANP [34].

A 2021 study scrutinized a difference in CT findings in acute pancreatitis in a group with and without intra-abdominal hypertension. A significant difference was disclosed in the presence, volume, and maximum size of clusters, volume of pleural effusion, and bile duct dilatation [35]. Compared with the results of our study, Pankaj Gupta et al found no difference in the presence of extrapancreatic necrosis, presence and area of pancreatic necrosis between patients with and without IAH. In order to compare the data, it is necessary to compare retrospectively the CT findings of our studied patients with ANP and selected patients without IAH.

In the presented study, the increase in IAP at the beginning of the disease affected only the volume of the extrapancreatic necrotic lesion. In the future, it is necessary to compare the values of IAP and EPN in one time interval and determine the critical level of IAP increasing the volume of EPN.

CONCLUSIONS

1. The increase in intra-abdominal pressure in the early phase of acute necrotizing pancreatitis was, on average, accompanied by an increase in the volume of extrapancreatic necrosis, ρ = 0.547 (p=0.0012).
2. No linear correlation was found between the level of intra-abdominal pressure and the degree of pancreatic necrosis (p>0.05).
3. In the studied sample, it was possible to predict the volume of extrapancreatic necrosis by measuring the level of intra-abdominal pressure in the early phase of the disease with an error of 15.02 ml. When the IAP level increases for each mm Hg., the volume of EPN increases, on average by 146.29±37.74 ml (p<0.001).
4. An increase in intra-abdominal pressure can be considered one of the markers of an increase in the volume of extrapancreatic lesions in patients with acute necrotizing pancreatitis.

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CONFLICT OF INTEREST

The Authors declare no conflict of interest

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A – Work concept and design, B – Data collection and analysis, C – Responsibility for statistical analysis, D – Writing the article, E – Critical review, F – Final approval of the article

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