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IS IT POSSIBLE TO PREDICT POSTOPERATIVE ABDOMINAL COMPLICATIONS BY LASER DOPPLER FLOWMETRY?

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ABSTRACT — In this study, the authors chose to assess the prognostic capabilities of the laser Doppler flowmetry method for postoperative complications in patients with advanced peritonitis. A retrospective randomized controlled trial (evidence level IIB) was performed. The study involved 54 patients who were operated on for secondary widespread fibrinous-purulent peritonitis. The patients were divided into two groups with 27 patients in each: the main group — with developed postoperative complications and a comparison group — without complications. The research was carried out by the analyzer "Lazma MC-1" (Russia). Scanning of the parietal and visceral peritoneum, small and large intestines, as well as the edges of the laparotomic wound was performed. A total of 504 scans were performed. The relationship of indicators was determined using the Spearman's rank correlation coefficient. Microcirculation indices in both groups were characterized by pronounced disorders of pre- and postcapillary resistance and disorders of tissue perfusion. The following indicators turned out to be statistically significant: percentage of microcirculation ($r= 0.77$ at $p\leq0.05$), standard deviation ($r = 0.67$ at $p\leq0.05$), coefficient of variation ($r = 0.59$ at $p\leq0, 05$) and shunting percentage. In patients of the main group, the changes were expressed in an increase in pre- and postcapillary resistance, progressive arterio-venular shunting. All this ultimately led to disturbances in the perfusion of the intestinal wall, peritoneum and laparotomic wound, which led to postoperative complications. The technique of abdominal laser Doppler flowmetry can be a prognostic method that allows predicting the development of early postoperative complications after primary surgery and making appropriate adjustments to the treatment.

KEYWORDS — surgical site infections, predicting postoperative complications, laser Doppler flowmetry, abdominal microcirculation , a randomized controlled trial.

INTRODUCTION

Surgical site infections (SSI) are a national priority in health research worldwide. The process of wound infection is complex and involves the interaction of several biological pathways at the molecular level. The incidence of postoperative infectious complications, even in developed countries, is 3–5%. Wound infections are the cause of high morbidity and mortality and can be as high as 33%. Current data indicate that surgical wound infections account for over two million nosocomial infections in patients hospitalized in the United States [1, 2, 3]. Many factors have been described that affect the prognosis of patients with SSI, including advanced age, poor nutrition, obesity, pre-existing medical conditions, immunosuppression, diabetes mellitus, advanced peritonitis, occurrence of septic shock, poor source control, organ failure, prolonged hospitalization prior to therapy, and infection with nosocomial pathogens, etc. [4, 5, 6].

Early prognostic assessment of complicated intra-abdominal infections is crucial for assessing the severity and making decisions about the aggressiveness of treatment [7]. In the postoperative period, the main therapeutic approach is to normalize the parameters of systemic hemodynamics using mainly vasoactive drugs and fluids. It is believed that the improvement in systemic circulation will lead to a parallel improvement in microcirculation. However, several studies on microcirculation in critical condition have found that persistence of microcirculatory changes can occur independently of systemic hemodynamic parameters, and that such loss of coherence is associated with poor outcome [8].

Over the decades, new instruments and methods for assessing microcirculation in critically ill patients were developed. In recent years, works on the use of laser Doppler flowmetry for intestinal obstruction, ischemic bowel damage and peritonitis have appeared in the scientific literature [9, 10, 11].

Lack of works devoted to predicting postoperative complications in generalized peritonitis using laser Doppler flowmetry (LDF) prompted this study.

MATERIAL AND METHODS

A retrospective randomized controlled trial (evidence level IIB) was performed. The object of the study was 54 patients who were operated on for secondary widespread fibrinous-purulent peritonitis in the period 2015–2020. Primary operations were carried out for

destructive diseases or injuries of the abdominal organs resulting from injuries. The duration of the disease ranged from 6 to 78 hours. The average age of the patients was 52 ± 4.2 years; there were 22 men, and 24 women. Criteria for inclusion in the study: severity of the condition according to APACHE II ≥ 10 points; SOFA ≥8 points. Exclusion criteria: peritonitis caused by impaired mesenteric circulation; peritonitis, accompanied by persistent arterial hypotension associated with extra-abdominal causes (myocardial infarction, stroke, etc.); decompensated septic shock; peritonitis associated withstage IV malignant neoplasms and abdominal carcinomatosis. All patients were divided into two equal groups (23 patients each), the main one — with developed postoperative complications and the comparison group — without complications. The patients were comparable by sex, age, severity of pathology, as well as the severity of diabetes mellitus. Postoperative complications in the main group were distributed as follows: local suppuration of the laparotomic wound — 12; incompetence of sutures of intra-abdominal anastomoses — 5; intra-abdominal abscesses — 5; eventration — 4; perforation of acute ileal ulcer — 1. According to the Clavien-Dindo classification, the distribution of postoperative complications was as follows: I-5; II-3; IIIa-5; IIIb-8; IVa-3; IVb-1; V-2.

All patients after laparotomy underwent LDF with a microcirculation and microlymph flow analyzer using the Lazma MC-1 apparatus (Russia). For the purpose of objectification, the indicators were taken within 1 min from 6 points: parietal peritoneum in the area of the focus; parietal peritoneum as distant as possible from the focus; jejunum (40 cm from Treitz's ligament); large intestine (middle third of the transverse colon); on both edges of the laparotomic wound (Fig. 1).We studied: the percentage of microcirculation (PM; c.u) — which is a function of the concentration of erythrocytes in the probed tissue volume and their average velocity; standard deviation (SD; σ, c.u.), i.e. average fluctuations in perfusion relative to the average value of PM — characterizing the temporal variability of perfusion and reflects the average variability of blood flow in all frequency ranges. Another indicator was the coefficient of variation (Cv;%) — it characterizes the relationship between the variability of perfusion with the average perfusion in the probed area, that is, it reflects the vasomotor activity of the vessels. In addition, the indicators obtained as a result of the wavelet transformation were also analyzed - neurogenic tone (NT), myogenic tone (MT), shunting percentage (SP) and microcirculation efficiency index (MEI). Data are presented as arithmetic mean and arithmetic mean error (M + m). The results obtained

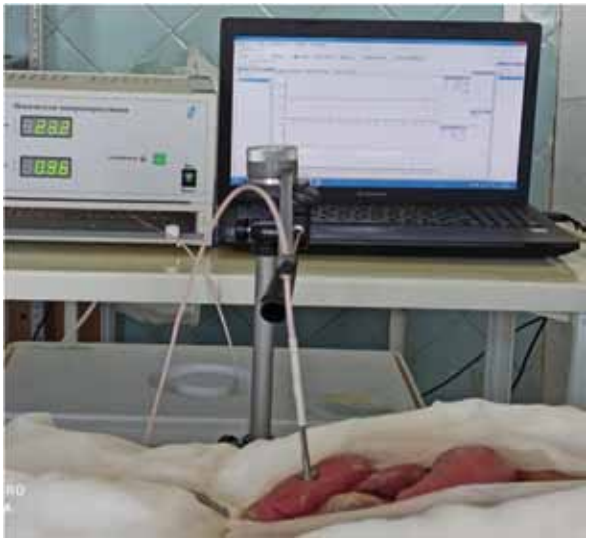

Fig. 1. *Laser Doppler flowmetry (scan of the jejunum)*

were compared with the reference values obtained in patients with elective surgery for non-inflammatory diseases of the abdominal organs (n = 30). Thus, 504 scans were performed in all groups.

Statistical relationships between indicators were assessed using Basic Statistics and Tables STATISTICA 6.0, regression analysis, analysis of variance, and multivariate statistics. The method of adaptive randomization was used. In order to determine the significance of p differences between groups, the Student's t test was used. Differences were considered statistically significant at $p \leq 0.05$. The relationship of indicators was determined using the Spearman's rank correlation coefficient.

RESULTS AND DISCUSSION

Microcirculation indices obtained with LDF in both groups were characterized by pronounced disorders of pre- and postcapillary resistance and disorders of tissue perfusion. In the main group, the values of PM, SD and Cv remained significantly lower in comparison with the comparison group ($p \leq 0.05$). MT and NT of peritoneal vessels, as well as MEI in the main group was comparatively lower, however, no statistically significant difference was found ($p > 0.05$). At the same time, SP in the main group increased statistically significantly ($p \geq 0.05$) (Table 1).

In order to identify and assess the tightness of the relationship between the two series of compared basic quantitative indicators of microcirculation (PM, SD and Cv) in the study groups, the Spearman rank correlation coefficient was calculated, which allows checking the heteroscedasticity of random errors in

Table 1. *Indicators of abdominal microcirculation in the study groups*

Indicators	Reference values (n=30)	Main group (n=27)	Comparison group (n=27)
PM (p.u)	32,21±1,18	17,6±1,55*	23,37±1,83*
SD (p.u)	5,42±0,33	2,03±0,19*	3,69±0,15*
Cv (%)	12,64±1,50	6,03±3,79*	11,34±4,04*
NT (p.u)	0,59±0,08	0,77±0,02	0,44±0,05
MT (p.u)	0,57±0,04	0,75±0,05	0,55±0,03
SP (p.u)	1,15±0,09	1,86±0,05*	1,18±0,03*
MEI	1,22±0,03	1,11±0,09	1,29±0,11

Note: ** — indicators with the value of changes p<0.05; p.u. — perfusion units; %*

the regression model. In the study of PM, there was a direct correlation with a high closeness of communication in the study groups (r = 0.77 at p≤0.05). (Fig. 2).

When carrying out the relationship in terms of Cv, data were obtained indicating a moderate direct correlation in the study groups (r = 0.67 at p≤0.05). (Fig. 3).

The study of the correlation relationship in terms of SD in the study groups revealed a direct relationship with a moderate closeness of communication (r = 0.59 at p≤0.05). (Fig. 4).

Currently, there are no objective methods that would reliably predict postoperative complications. The prognostic risk scales of surgical site infections developed on the basis of meta-analyzes (ASA, CDS, SSIRS, qSOFA, etc.) are often quite massive and of little use in urgent surgery. This undoubtedly requires a search for alternative methods for predicting postoperative complications in patients with urgent intra-abdominal pathology [12].

A study on the abdominal microcirculation in generalized peritonitis showed significant disorders, which were expressed in changes in pre- and post-capillary resistance, leading ultimately to disorders of perfusion of the intestinal wall, peritoneum and laparotomic wound. A statistically significant decrease in PM and SD values indicated a decrease in the concentration of erythrocytes, suppression of perfusion fluctuations, and the Kv indicator showed a decrease in vasomotor activity of the vessels. Progressive arterio-venular shunting further aggravated cellular hypoxia, which was confirmed by changes in the SP index. All of the above changes led to postoperative complications. The study has shown that LDF can be a prognostic method that allows predicting the development of postoperative complications after primary surgery and making corrections in treatment.

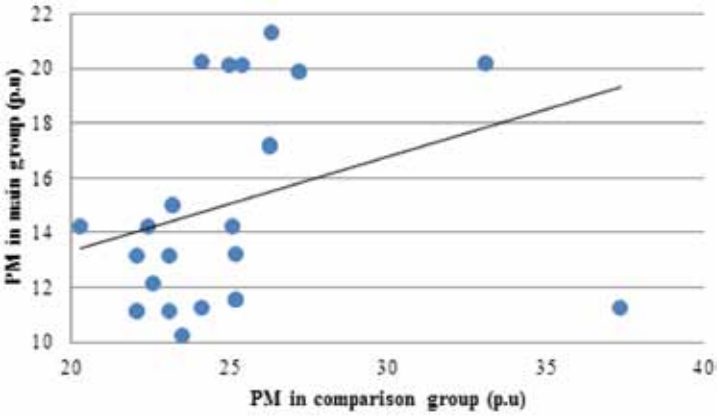

Fig. 2. *Spearman's rank correlation coefficient for the PM parameter in the study groups (r = 0.77 at p<0.05)*

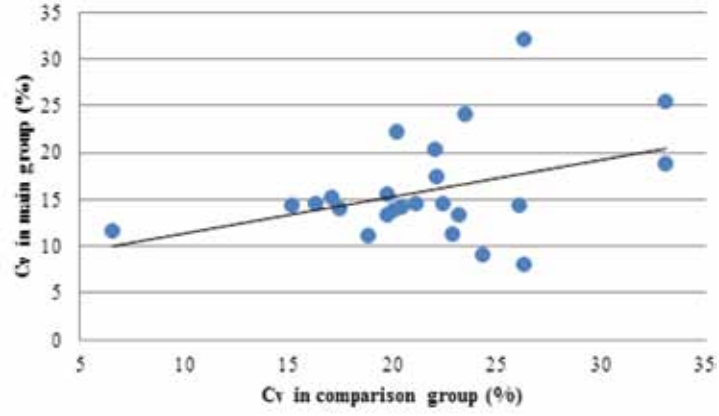

Fig. 3. *Spearman's rank correlation coefficient for the Cv parameter in the study groups (r = 0.67 at p<0.05)*

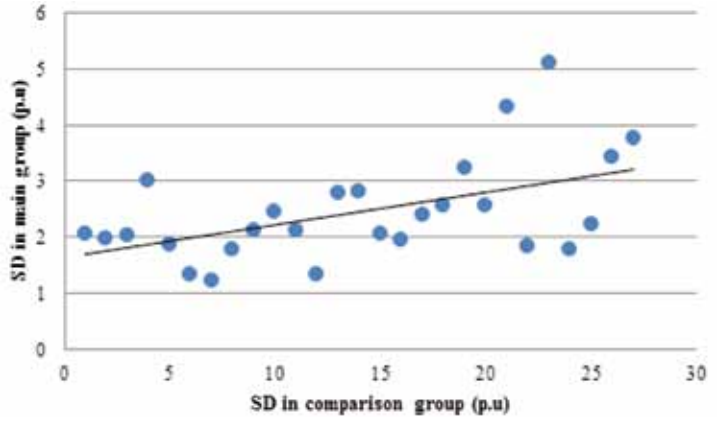

Fig. 4. *Spearman's rank correlation coefficient for the SD parameter in the study groups (r = 0.59 at p<0.05)*

CONCLUSION

The data obtained as a result of a retrospective randomized controlled trial allow us to conclude that

the abdominal LDF technique allows predicting early postoperative complications in patients with advanced peritonitis. The data can be used to develop an objective predictive system.

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