

The Evaluation of Electrophysiological Methods of Research in Diagnosis and Prediction of Early Intra-abdominal Complications after Colon Surgery

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Abstract

Objective: To assess the effectiveness of electrophysiological methods of research in diagnosis and prediction of early intra-abdominal complications after colon surgery.

Background: The main reason of unsatisfactory results of early intra-abdominal complications treatment after colon surgery is delay in diagnosis of these complications and late repeated surgery.

Methods: Electrophysiological method used in study includes complex installation of sensor system that registers simultaneously a number of physiological parameters.

Results: With a favorable course in the early postoperative period there was a gradual decrease in the sensitivity threshold of the colonic wall according to current strength from 19 ± 4.2 to 9 ± 3.6 mA on the third day after the surgical intervention. If there were intra-abdominal complications in the early postoperative period, the threshold indices varied from 14 ± 2.9 to 24 ± 3.7 mA, and subsequently it happened that they ceased to be detected.

This gives us the opportunity to start active methods of detoxification in the treatment group on 18-22 hours earlier than in the control group of patients. In addition, the periods of repeated lavage of the abdominal cavity decreased by (20.0 ± 0.3) hours in comparison with the control group. Mortality in the control group is 28.1%, in the treatment group-19%.

Conclusions: Comparing the results of treatment of the main and control groups, it should be noted that the early intra-abdominal complications are diagnosed much earlier in the treatment group of patients, primarily due to the results of electrophysiological research methods.

Keywords: Electrophysiology; Early intra-abdominal complications; Colon surgery

Introduction

Despite the success of modern abdominal surgery, the risk of the early postoperative intra-abdominal complications after urgent and planned operations on the abdominal cavity organs remains high. The frequency of repeated interventions performed because of the early postoperative intra-abdominal complications is from 0.5% to 8.6% according to the data of different authors [1-4] and lethality (mortality) in case of repeated interventions is according to the data of a number of authors observed from 40% to 80%.

The main reasons of unsatisfied results of the early intra-abdominal complications treatment after surgery on the colon are untimely diagnosis of these complications and delay in the performance of an adequate medical intervention. The difficulties of diagnostics are complicated by some objective reasons such as the use of analgesic and antibacterial drugs in the early postoperative period, multipurpose

intensive therapy and by subjective negativism of a surgeon and a patient to repeated surgery.

According to the current concept, the triggering mechanism of dynamic ileus during inflammatory postoperative intra-abdominal complications is a deep inhibition of motility, leading to disruption of evacuation and further deterioration of muscle activity [5,6]. The directly-proportional dependence between the degree of the gastrointestinal tract paresis, the severity of endogenous intoxication and postoperative lethality (mortality) is established [5].

It is also known that after major surgery on the organs of the abdominal cavity the intestinal peristalsis (intestinal motility) begins to be heard only on the third day, and sometimes even later. Therefore, according to these data it is difficult to assess the prognosis of disease on the first day after the operation [7]. In this regard, an actual problem of surgery is the identification of criteria for the timely diagnosis of postoperative complications.

The above circumstances determine the necessity to use new methods for the diagnosis of early postoperative intra-abdominal

complications, which allows identifying complications before clinical presentations.

Our long-term experience in the study of the functional state of the gastrointestinal tract conducted by the electrophysiological laboratory of the clinic enabled us to use the proposed methods for studying the contractile activity of the intestinal musculature for diagnosis of postoperative intra-abdominal complications at the early stage.

The purpose of the work is to evaluate changes in the contractility of the neuromuscular apparatus of the colonic wall during the normal course of the postoperative period and at the stages of intra-abdominal complications due to the determination of the local "autonomic motor function" of the colonic wall [8-10].

Methods

For the detection of early postoperative intra-abdominal complications after colon surgery, our studies are aimed at: Identification of the most typical clinical signs and symptom complexes, which are common for early intra-abdominal complications after colon surgery; Evaluation of the laboratory possibilities and instrumental methods of diagnosis of early postoperative intra-abdominal complications using X-ray, ultrasound, laparoscopic, electrophysiological methods and objectivity determination in diagnosing of various complications after colon surgery; revealing the most informative electrophysiological parameters that characterize the dynamics of the course of the early postoperative period after colon surgery.

To characterize a number of parameters of the contractile function of the gastrointestinal tract, we use a complex physiological device consisting of a system of sensors [10,11].

This device allows to perceive and record from the same section of the gastrointestinal tract the following physiological parameters: The intracavitary pressure, the pressure of the wall of intestine, the sensitivity threshold of the colonic wall and the excitability threshold of the colonic wall in terms of current strength.

The constructed electrophysiological devices and the sensor system make it possible to perform separate and simultaneous recording of the pressure of the colonic wall and intracavitary pressure in the cavity under study. The use of the sensor of respiratory excursions and the selective element allow to exclude the influence of the respiratory act on the obtained results and to improve the accuracy of measurement of motility of the colon.

As a stimulating device for transrectal contact dosage electrostimulation of the colon, a constant current generator was used in the range of 3 to 35 mA. It has three independent channels, which are controlled by three independent switches. A three-channel device with a three-channel probe with three small balloons (up to 2 cm³) located 5 cm apart from each other is used for simultaneously registration of the contractions of the studied colon area. The graphical record was recorded on a computer [12,13].

Background and stimulation motility of the colon and rectum are studied by the method of multichannel balloonography. Insertion of the probe into the lumen of the intestine was carried out through the proctoscope tube under the control of the vision for the depth required for the study. In the cases of severe patients, a miniature balloon and an open catheter were used as a sensor in the early postoperative period.

Electrodes for supplying electric current for the purpose of electrostimulation and subsequent registration of the colonic wall reaction to irritations were placed on the balloon. The sensor to such patients was injected into the rectum after a finger examination.

We examined 28 apparently healthy people who did not have gastrointestinal pathology-volunteer students from Donetsk Medical University. The average age was 24 years. 73 studies were carried out. The electrophysiological study included the determination of the following physiological parameters from the same part of the colon: Intracavitary pressure, colonic wall pressure, bioelectrical potentials and threshold of the sensitivity of the colonic wall by current strength.

Qualitative assessment of the colon's motility consists in describing the shape of the frequency, the duration of contractile waves, the intensity of the response of the colonic wall to irritation and fluctuations in the intracavitary pressure.

Electrophysiological methods for diagnosing early postoperative intraperitoneal complications are based on the dynamic control of the functional state of the colonic wall, the change of which is recorded earlier than the clinical signs of the state change and the results of laboratory or other research methods [14,15].

To assess the "local autonomous function" of the colonic wall in the early postoperative period, when there are no own contractions, stimulation mechanocolography was registered. It is based on a well-known fact: The electrical current response to stimulation, in the form of a contraction even in the first day after surgical interventions on the colon.

Statistical evaluation was done using SPSS (version 14.0 for Windows; SPSS Inc., Chicago, IL). Differences between the 2 groups were analyzed using a χ^2 test, the Fisher exact test, or Mann-Whitney U test, as appropriate, with P value of <0.05 deemed to be statistically significant.

Results

The results of surgical treatment of 1123 patients operated on the colon were analyzed, 224 patients (20.8%) had early postoperative intra-abdominal complication, 38 of them were urgently operated because of peritonitis.

Patients were treated in the Proctology department of the Donetsk Regional Clinical Territorial Association and in the Department of Abdominal Surgery of the Institute of Urgent and Recovery Surgery of V.K.Gusak of National Academy of Medical Sciences of Ukraine (from 2007 to 2018).

Those complications that occurred during postoperative period and were associated with a surgical intervention on the colon were included to the early intra-abdominal complications. In terms of time, it coincided with the time immediately after the surgery and before patient discharge from the hospital (Table 1).

Depending on the methods of diagnosing early intra-abdominal complications after colon surgery, all patients we examined were divided into 2 groups. The I (control) group consists of 103 patients and the well-known diagnostic methods for the diagnosis of early intra-abdominal complications were used: clinic, laboratory methods of research, radiography, ultrasound, computed tomography, laparoscopy.

The II (treatment) group includes 121 patients. For these patients well-known methods with electrophysiological methods of investigations were used. The age of patients was from 19 to 92 years.

The structure of early complications after colon surgery is presented in Table 2.

| Nature of Pathology | Treatment group (n=121) | | Control group (n=103) | | Total (n=224) | |
|-------------------------------|-------------------------|------|-----------------------|------|---------------|------|
| | Abs. | % | Abs. | % | Abs. | % |
| Colon cancer | 60 | 49.5 | 58 | 56.3 | 118 | 52.6 |
| Diverticular disease of colon | 11 | 9 | 10 | 9.7 | 21 | 9.3 |
| Chronic colonic stasis | 17 | 14 | 12 | 11.6 | 29 | 12.9 |
| Reparative operation | 10 | 8.2 | 9 | 8.7 | 19 | 8.4 |
| Colon trauma | 6 | 4.9 | 5 | 4.8 | 11 | 4.9 |
| Other diseases | 17 | 14 | 9 | 8.7 | 26 | 11.6 |
| Total | 121 | 100% | 103 | 100% | 224 | 100% |

Table 1: Distribution of patients (who had intra-abdominal complications after colon surgery) by the nature of the pathology in the control and treatment groups.

| Nature of complications | Treatment group (n-121) | | | Control group (n-103) | | |
|---|-------------------------|------|------|-----------------------|------|------|
| | Abs. | % | died | Abs. | % | died |
| Postoperative peritonitis | 61 | 50.4 | 20 | 59 | 57.2 | 23 |
| Early ileus | 28 | 23.1 | 1 | 12 | 11.6 | 2 |
| Peritoneal abscess (intraabdominal abscess) | 12 | 9.9 | - | 13 | 12.6 | 1 |
| Eventration | 6 | 4.9 | - | 4 | 3.8 | - |
| Intra-abdominal hemorrhage | 5 | 4.1 | - | 8 | 7.7 | - |
| Others | 9 | 7.4 | 2 | 7 | 6.7 | 3 |
| Total | 121 | 100% | 23 | 103 | 100% | 29 |

Table 2: The structure of early complications.

Comparative analysis of the complication structure among patients of the main and control groups do not reveal significant differences ($p>0.05$). This is due to the uniformity of the pathology of the colon and the nature of surgical interventions in these groups.

Out of 103 patients in the control group 29 patients died (28.1%), out of 121 patients in the main group, 23 (19%) died.

The onset of deaths in patients with early postoperative intra-abdominal complications after colon surgery was facilitated by many factors, among which the main ones are the diagnosis of the underlying disease, the type of complication, the timing of its diagnosis and the performance of repeated surgical intervention.

Our study shows that on the second day after the operation with complicated colon diseases, the background motor activity is not recorded.

However, the intracavitary pressure of 34 patients remains quite high, 28.0 ± 0.8 mm/wg. The size of the intracavitary pressure mainly depends on the severity of the inflammatory process in the abdominal cavity. The heavier the overall condition of the patients, the lower indices of the intracavitary pressure are of the rectosigmoid part of the

colon. 12 patients with a common peritonitis have the intracavitary pressure decreased to 5.0 ± 0.9 mm/wg.

It should be noted that the indicators of the intracavitary pressure during these periods do not change throughout the entire recording, they are permanent. By these values, we characterize the condition of the tone of the colonic wall.

The indices of intracavitary pressure in these patients in the rectum are on average, 18.0 ± 0.6 mm/wg. 27 patients of the treatment group, who subsequently noted the progression of peritonitis, had a gradual decrease in the pressure indices of the same colon section and in 7 patients reached zero at these times. It should be noted that in those patients who subsequently resolved peritonitis, at the end of the 3rd day there were fluctuations in the amount of intracavitary pressure of the distal part of the colon. These unobtrusive changes in the magnitude of the intracavitary pressure are a harbinger of the onset of contractions of the entire intestine.

On the third and fourth days those patients who later survived, had on the mechanocology the appearance of rare low-amplitude background contractions in the form of waves of the I-II type, the

average amplitude of the reduction waves was 12.0 ± 0.5 mm/wg. The size of the intracavitary pressure began to increase gradually and took on a wavy character. The value of the intracavitary pressure during these periods was within 32.0 ± 0.7 mm/wg.

The data on the threshold of the sensitivity of colon were statistically processed. On the fourth day after the operation, in all patients of this group there was a further decrease in the threshold of the sensitivity of colon on the strength of the current. The average threshold in these patients was on the average 13.0 ± 0.7 mA. According to our data, the value of the threshold of the sensitivity of colon on the strength of current is the most sensitive and informative in determining the dynamics of changes in intestinal motility in peritonitis.

The electrophysiological parameters characterizing motility of the colon worsened in those patients who had progressive peritonitis. In particular, in all 6 patients from the treatment group, who subsequently died within 2 to 9 days after the operation from the progression of peritonitis, intracavitary pressure of the rectum progressively decreased. At mechanocolography no waves appeared.

Threshold of the sensitivity of colon on the strength of the current progressively increased and subsequently ceased to be determined. All these changes corresponded to the progressive worsening of the general condition of these patients.

| Time after surgery | Threshold of sensitivity of colon by current strength (mA) with favourable outcome | Threshold of sensitivity of colon by current strength (mA) with adverse outcome |
|--------------------|--|---|
| Day 1 | 21.0 ± 0.5 | 22.0 ± 1.0 |
| Day 2 | 15.0 ± 0.3 | 26.0 ± 0.5 |
| Day 3 | 11.0 ± 0.4 | 30 and more, more frequently not identified |

Table 3: The dynamics of the threshold of sensitivity of colon in the early postoperative period, depending on the outcome of the disease.

As our studies have shown, the electrophysiological parameters of the colon can be used to diagnose the degree of intestinal motility disorder in peritonitis. In connection with this, we have developed a new method for assessing the degree of compensation of motor function of the colon with peritonitis. A patent of Ukraine is received for utility model No. 23144 dated 10.05.2007. The essence of the method is the next: by the character of the mechanocolography and the corresponding reaction of the colonic wall to irritation it is able to determine the degree of compensation of the contractile function of colon.

To reveal the degree of compensation:

- **Compensated:** When the nerve receptors of the colonic wall adequately react to stimulation at current strength 7.0 ± 4.2 mA;
- **Subcompensated:** When the nerve receptors of the colonic wall are slightly irritated and for the excitation it is necessary to increase the current to 17.0 ± 6.3 mA;
- **Decompensated:** When the receptors of the colonic wall lose the ability to perceive irritation even when the current strength of up to 30 mA.

Discussion and Conclusion

Comparing the results of treatment of the main and control groups, it should be noted that the early intra-abdominal complications are

The lack of positive dynamics of the electrophysiological parameters characterizing the contractile activity of the intestine that starting from the third day and further along with the indicators of general clinical methods of investigation should be regarded as an alarm signal. Therefore, the progression of the inflammatory process in the abdominal cavity is possible, the further tactics of treatment should be considered.

Table 3 shows the dynamics of the threshold of the sensitivity of colon, depending on the outcome of the disease.

As can be seen from Table 3, if the level of the threshold of the sensitivity of colon by the current strength is reduced in dynamics, then this is a good prognostic sign. This resulted in the subsequent restoration of intestinal motility and favorable outcome of the disease. However, if the threshold of the sensitivity of colon by current strength is increased in dynamics, this led to the progression of the pathological process in the abdominal cavity. The rise of the threshold of sensitivity of colon in dynamics in the early postoperative period was revealed in 64 patients (52.8%), 53 of them were reoperated, 13 of them-twice, two to three times, 23 patients died.

diagnosed much earlier in the treatment group of patients, primarily due to the results of electrophysiological research methods. This gave us the opportunity to start active methods of detoxification in the treatment group on 18 ± 22 hours earlier than in the control group of patients. In addition, the periods of repeated lavage of the abdominal cavity decreased for 20.0 ± 0.3 hours in comparison with the control group. The control of the effectiveness of the therapy is another crucial point. All this results enabled us to statistically significant ($P < 0.05$) reduction in the duration of intestinal paresis in the treatment group at 14.0 ± 0.3 hours. The mortality in the control group was 28.1%, in the treatment group - 19%.

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