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OPPORTUNITIES OF GAS DISCHARGE VISUALIZATION TECHNIQUE IN THE ESTIMATION OF FUNCTIONAL STATE OF THE ORGANISM IN MONITORING OF PATIENTS STATE AFTER ABDOMINAL SIRGERY IN PERIOPERATIVE PERIOD WITH THE "GDV CAMERA"

Polushin[1] U.S., Strukov[1] E.U., Levshankov[1] A.I., Shirokov[1] D.M., Korotkov[2] K.G.

E-mail: shirokov@mail.lanck.net

[1]Military Medical Academy, St. Petersburg, Department of anesthesiology and resuscitation; [2] University "SPITMO", St. Petersburg

INTRODUCTION

At the present stage of medicine development more and more attention is paid to various noninvasive methods, including electrophysiological, of the investigation of functional state of vitally important systems of organism. Modern computer technologies used for the processing of data obtained by means of such methods enable to significantly speed up the process of obtaining the results of research, to standardize the technique, as well as to decrease the influence of a subjective factor on the received results.

One of the most promising electrographic methods for estimation of the functional state of an organism is the Gas Discharge Visualization (GDV). The technique is based on the registration of glow stimulated by photons and electrons, as well as other particles near the surface of biological objects placed in a high intensity electromagnetic field. It is supposed that the biological emission enables estimations of the entropy of human energetic states (K. Korotkov, 1995, 2000, 2001).

At present this technique is quite actively used in various spheres of medicine – therapy, oncology, obstetrics, gynaecology, and psychophysiology (Gurvitz B.L., et al., 1998; Alexandrova R.A., et al., 1999, 2000, 2001; Azheulov A.U., 2000; Bundzen P.V., et al, 2000; Gimbut V.S., 2000; Bundzen P., Unenstahl L.E., 1999; Kolmakow S. et al., 1999). This study is the first application of the technique for estimating the functional status of perioperative patients. The attractiveness of this method from the viewpoint of electrophysiology, as well as the previous absence of data on the possibility of its application in the interests of anaesthesiology has been the basis for the performance of our research.

Advantages of GDV technique:

- Possibility of screening and monitoring the entropy-energy homeostasis of organism and its particular systems;
- Potential application as a method of express screening diagnostics;
- Objectivity of information (independence from experience of a particular user);
- Noninvasiveness, safety;
- Monitoring of processes in time, i.e. estimation of dynamics of state and/or disease;
- Methodical simplicity and convenience (absence of any special requirements to the room, environmental conditions, professional skills of operator);

❖ Application of modern techniques of non-linear mathematics for the processing of fractal images and extraction of information on patient's state; objectivity and interpretability of the results received, convenience of storage and processing of results.

Aim. To estimate the informativeness of the GDV technique from the viewpoint of anesthetist during functional examination of patient in pre- and postoperative periods.

Summary Findings

1. There are reliable differences between parameters of GDV-grams of practically healthy people and patients with chronic abdominal surgical pathology.
2. The data obtained indicate that GDI parameters are connected with the functional status of the organism and reflect the severity of the somatic state of patients with abdominal surgical pathology.
3. The most informative parameters are: "integral area of glow JS" in the "GDV Diagram" program; "total" and "normalized area", "total density", "average brightness", as well as "fractality" and "form coefficient" in the "GDV Processor" program.
4. The most informative mode of registration of GDV-grams is the mode "without filter". On the whole, the application of the filter keeps the trend of changes, but they are often less pronounced and lose statistical significance.
5. The revealed variability of GDV-gram parameters depending on the sex and age of patients indicates that it is necessary to determine their individual norms.
6. The dependence of perioperative dynamics of a number of indices on the severity of the patient's somatic state, the patient's age and the duration of surgical procedure enables functional monitoring in the postoperative period, and evaluation of operative stress.

Research Methods

At the first stage, two groups were gathered: the control group, including 35 practically healthy people, and the main study group, consisting of 96 patients with chronic surgical pathologies in organs of the abdominal cavity. The differences in the GDV parameters for healthy people and patients were found, and the influence of various factors on the parameters was assessed (sex, age, main pathology).

All patients were divided into three groups according to the degree of severity of their state, using criteria accepted in military-medical institutions of the armed forces of the Russian Federation.

I group was made up by patients having the 1st degree (least) severity of the somatic state. **II group** consisted of patients with the 2nd degree of severity. **III group** was made up by patients with the 3rd-4th degree of severity.

General characteristics of patients are given in table 1.

Table 1

General characteristics of patients

Parameters	Groups		
	I	II	III
Number of patients	22	46	28
Male	9	13	14
Female	13	33	14
Somatic state of patient, degree	1	2	3-4
Middle age, years	32.1±2.6**. ***	53.2±1.4*. ***	62.9±2.4*. **
Body weight, kg	76.5±3.5	77.5±2.2	74.5±2.4
Height, cm	167.5±2.4	165.7±1.2	165.9±1.2

Note: * – $p<0,05$ in comparison with group I, ** – $p<0,05$ in comparison with group II,

*** – $p<0,05$ in comparison with group III.

The GDV-gram parameters were compared with data received in the course of physical and instrumental examination of patients (integral rheography of the body, spirography). Multifactor regression and correlation analyses were used in order to reveal dependence between these parameters.

The patients were examined at the following stages:

I – the day before the planned operative intervention, with the purpose of detecting initial GDV-gram parameters;

II – in the closest postoperative period (during the first hour after the operation);

III-V – in early postoperative period from the 1st day to the 3rd inclusive;

VI – on the 5th day of postoperative period.

For monitoring the state of patients in the postoperative period, including the evaluation of postoperative stress, all patients were divided into four groups depending on the anatomical area where the surgery was performed, and taking into account the technique of operation.

1st group. Surgical operations in gall-bladder and bile-excreting tracts by laparoscopy (laparoscopic cholecystectomy). 47 patients (30 women and 17 men).

2nd group. Surgical operations in gall-bladder and bile-excreting tracts by conventional cholecystectomy. 14 patients (8 women and 6 men).

3rd group. Surgical operations in abdominal area and duodenum. 18 patients (5 women and 13 men).

4th group. Surgical operations in different parts of the large intestine (mainly resection of the large intestine and rectum, hemicolectomy regarding cancer of colo-rectal localization). 12 patients (9 women and 3 men).

Subgroups depending on the severity of the somatic state in the preoperative period were distinguished within each anatomical group of patients. Only the 1st group (laparoscopic surgeries) included a subgroup of patients initially having the 1st degree of severity of the somatic state. The severity of the somatic state of all patients in other groups was assessed as the 2nd and 3rd-4th degree (II and III subgroups, respectively).

Anesthetic management of surgeries in gall-bladder and bile-excreting tracts (1st and 2nd group) was performed in accordance with the standard method (general combined anesthesia with intubation of trachea and artificial pulmonary ventilation). The epidural anesthesia and general combined anesthesia with intubation of trachea and ALV was used for the majority of abdominal surgeries (3rd group) and also surgeries in different parts of large intestine (4th group).

The reaction of the organism to the trauma was investigated based on the dynamics of the main GDV-gram indices in addition to changes in the clinical picture, hemodynamics, and biochemical indices of blood (glucose, aminotransferases, etc.).

Possible application of the GDV technique for a prognosis of unfavorable flow in the early postoperative period was assessed in the final stage of this research. Patients with acute postoperative pancreatitis (OPP) were distinguished from the main group. GDV-gram parameters of the OPP group were compared with patients showing usual postoperative processes.

Results of research

1. Assessment of individual characteristics of GDV-gram parameters

Comparison of the control group with the subject group showed reliable increases in the GDV parameters of area, brightness, density, and irregularity of the outer contour of the glow in the subject group. In addition to present pathology, other factors such as age and sex influenced GDV parameters. All fifty-six parameters processed in the GDV Diagram program showed increases with age, but only the JS parameter changed reliably in all the age categories (fig. 1).

Measurements with filter showed the rising tendency, but were not reliably statistically significant.

Parameters obtained in the GDV Processor" program also demonstrated pronounced dynamics with age in the majority of cases. With age increase of GDV Area, decrease of density and brightness, and flatness of outside contour were statistically significant ($p < 0.01$). This may be correlated with increase of organism entropy with age in accordance with the concept presented in [Korotkov, 2002].

The differences obtained indicate that it is necessary to determine the age norm of GDV-gram parameters. Characteristic changes of GDV-grams in various age categories also gave us a key to the interpretation of dynamics of the same indices in perioperative period, since age rise of a series of GDV-gram parameters obviously corresponded to the age decrease of functional reserves of the organism.

The examination of women demonstrated that their GDV-grams differ from men's GDV-grams in a series of parameters and are characterized by reliably high values. Parameters in the GDV Diagram program showed reliable differences only in the registration mode "without filter". Parameters in the GDV Processor program showed reliable differences both with and without filter. More differences were found to be significant in the data taken without filter.

The most informative parameters in this analysis were JS in the GDV Diagram program, parameters of "area" (total, and, to a greater extent, normalized area), "total density" and "average brightness" of glow, as well as irregularity of the GDV-gram outer contour (fractality and, to a greater extent, form coefficient) in the GDV Processor program. The individuality and variability of GDV-gram parameters indicate that it is necessary to study the differences of these parameters in equivalent groups. In this case, studying people for the purpose of discovering some kind of pathology of functional systems, could hardly be considered correct without taking into account various circumstantial factors.

We compared parameters of GDV-grams of practically healthy women and women with chronic abdominal pathology in one age category from 20 to 40 years. The results of analysis allowed distinguishing certain reliable differences between these groups. The amount of differences turned out to be lower than when the age and sex characteristics had not been taken into account. The comparison of women in one age category (older than 60 years), with and without an oncology as the main pathology, showed reliable differences between GDV parameters. The results of this analysis demonstrated that, on average, the value of GDV-gram parameters for women with oncological pathology as the main pathology was lower than for patients of the same age category who had never had cancer diseases.

GDV-gram parameters of patients with pathologies are different from healthy people. However, the GDV are very individual and depend not only on the pathological changes in the organism but also on sex and age, as well as, most probably, on other factors. At the present stage of development of the method, these considerations make it suitable not for the comparative research or diagnostics of diseases, but rather for the dynamic observation of changes in the patient's bioenergy status.

2. Investigation of informativeness of the GDV technique for the examination of functional state of patients in preoperative period

GDV-gram parameters showed reliable differences depending on the degree of severity of the somatic state It was demonstrated that there are reliable differences between them. Patients of the III group (most severe) were characterized by lower GDV-gram parameters. The GDV-grams of patients who had high values for the severity of somatic state were characterized by smaller area and brightness of GDV glow, as well as smoothness of its outer contour (direct correlation with fractality). The JS index reliably differed only when the GDV-grams were registered "without filter" (fig. 2).

We can argue from the bioenergy point of view that the decrease in these parameters for patients with more severe somatic states is governed by low functional reserves of the organism.

The obtained data show that GDV-gram parameters reflect the severity of the somatic state of patients with abdominal surgical pathology.

3. Estimation of possibility of application of GDV technique for the monitoring of functional state of patients in postoperative period

Analysis of GDV-gram parameters in the postoperative period showed the most pronounced changes during the first day after the surgery. Most of the main parameters registered within the first hour after the surgery reliably increased, as compared to the preoperative measurements. JS measured without filter increased (fig. 3). The parameters of "normalized" and "total area" in "GDV Processor" program were changing in a similar way.

The outer contour of the GDV-gram also changed in response to the operative trauma, shown in the increase of "fractality" and decrease of "form coefficient". When the image filtration was used, reliable differences were registered only for the "form coefficient" index. Reliable changes of the "brightness of glow" were not fixed.

We suppose that such a dynamics of parameters of GDV-grams is connected with the strain of functioning of all the systems and organs in response to the operative trauma, i.e. with the operative stress.

The dynamics of GDV-gram parameters, received during the first hour after different surgical interventions, was analyzed with the purpose of studying the possibility of using the GDV technique for the estimation of operative stress. The dynamics of GDV-gram area parameters in response to surgeries differing in volume and character was determined for the patients of II group (2 degree of severity state according to ASA), taking into account that the GDV-gram parameters depend on patient's age and severity of state. The most informative indices – JS and "normalized area" were used (fig. 4, 5).

The analysis of data given in the figures demonstrated that the most significant shifts took place after surgical interventions by cholecystectomy. Significant changes were found after all the gall-bladder, bile-excreting tracts, and abdominal surgeries, connected with the fact that the biggest amount of extended and simultaneous surgeries were performed in these groups. As a result, surgical interventions in the upper part of the abdominal cavity were the longest and most traumatic. The changes of parameters of GDV-gram area after large intestine surgeries were less expressed, andthe changes of these parameters after laparoscopic surgeries were even smaller.

Thus, we can conclude that the GDV technique can be used for the evaluation of the degree of operative stress.

The analysis of dynamics of GDV-gram parameters in early postoperative period after similar surgeries in different severity subgroups demonstrated that stronger changes were expressed for patients with the 1st degree of severity (least severity). This strong response was specially registered after the surgeries by laparoscopy (I group), including all the three severity subgroups (fig. 6). Similar dynamics were shown in the group of patients who bore traditional (laparotomic) cholecystectomies (II group). A less expressed reaction of GDI "area" parameters in response to surgery was registered for patients with a more severe state (subgroup III), reflecting the decrease of compensatory possibilities for reaction in the organism. In addition, parameters of GDV-gram area declined after larger and longer surgeries (abdominal and large intestine surgeries, 3rd and 4th groups, respectively) (fig. 7, 8).

While the changes of GDV-gram parameters in response to the considered surgeries in severity subgroups I and II were characterized by an increase of "area of glow", a significant decrease of this index was registered for patients of the most severe subgroup III in the 3rd (abdominal) and 4th (intestinal) anatomical groups when examined in the first hour after the surgery.

We assume that such a decrease of "area of glow" after large surgery interventions characterizes the state of distress and reflects low functional reserves. The consequence was often a longer period spent in intensive care and therapy units (ICTU) and generally a longer stay in a hospital, as well as more frequent development of complications and lethal outcomes in

the early postoperative period (table 2).

Thus, based on the obtained data, we can conclude that the GDV technique provides for monitoring the functional state of patients in a postoperative period.

Table 2

Frequency of development of complications and lethal outcome in early postoperative period for patients of various groups

Parameters	Subgroups of patients		
	I	II	III
Number of patients	22	46	28
Extent and character of surgery, degree	2.08±0.08	2.51±0.12	2.71±0.14
Age, years	32.12±2.57	53.22±1.45	62.89±2.39
Days in bed in ICTU	0.83±0.21	2.49±0.35	4.21±1.21
Total amount of days in bed	6.62±1.42	21.35±4.64	27.35±5.23
Frequency of development of complications, absolute number	-	9	14
Lethal outcome, absolute number	-	-	2

4. Assessment of possibility of application of the GDV technique for the prognosis of unfavorable flow of the early postoperative period

The *"**unfavorable prognosis**"* assessment was made on the basis of the clinical picture, data of laboratory and instrumental diagnostics for 12 patients. It was confirmed by the calculation of the diagnostic index according to the method acknowledged in the clinic of anesthesiology, reanimation, and intensive therapy of the Military-Medical Academy (Suhovetsky A.V., 2001).

The GDI parameters of these ***"unfavorable prognosis"*** patients were compared with the data received for patients with a usual flow of the postoperative period. Reliably high values of the parameters "area of glow", "density", and "fractality" of GDV-grams were characteristic of the *"**unfavorable prognosis**"* patients. The "average brightness" parameter was reliably lower for the *"**unfavorable prognosis**"* patients. These differences were already registered in the preoperative period, and had the most pronounced character in the first day after the surgery, when there were not yet reasons to make the *"**unfavorable prognosis**"* assessment from the results of the clinicolaboratory measurements. These data provide evidence that the GDV technique is quite a sensitive method, enabling us to identify possible inadequate reaction of the organism to a surgical challenge. However, further research is needed for a complete interpretation of the obtained results.

Thus, the results of our research, on the whole, allow maintaining that the GDV technique is a perspective method to be applied in surgery and anesthesiology departments for the functional examination of patients and monitoring of their state in perioperative period.

CONCLUSIONS

1.The parameters of GDV-grams reliably differ for practically healthy people and patients with chronic abdominal surgical pathology.

2.The parameters of GDV-grams are connected with the functional status of the organism and, to a certain extent, reflect the severity of the somatic state of patients with abdominal surgical pathology.

3.The most informative parameters of the GDV technique are: "integral area of glow JS" in "GDV Diagram" program, "total" and "normalized area", "total density", "average brightness", as well as irregularity of the outer contour of the GDI ("fractality" and "form coefficient") in "GDV Processor" program.

4.The mode "without filter" shall be considered a more efficient mode of registration of

GDV-grams. The mode “with filter” generally keeps the trend of changes, but makes them less pronounced and often unreliable, which reduces the sensitivity of the method.

5.The parameters of GDV-grams are individual and depend on the sex and age of patients, which indicates that it is necessary to determine their norm range.

6.The parameters of GDV-grams reliably change in response to the operative trauma, and their dynamics depend on the severity of the somatic state of patient, which allows using the technique for functional monitoring of patients in postoperative period, as well as for the assessment of the operative stress.

PRACTICAL RECOMMENDATIONS

1.The Gas Discharge Visualization technique is mostly advisable for the dynamic assessment of the functional state of patient in perioperative period. Not all the fingers shall be used, at that, but only one finger of each hand. For example, the fourth finger, where the GDI changes are the most significant.

2.The perfection of the hardware and, first of all, the decrease of the size of the sensor for the GDI registration and development of the means of its fixation on patient’s finger are needed in order to further practically apply the GDV technique in surgery and anaesthesiology.

3.It is enough to use the most informative parameters of GDV-grams for the application of the GDV technique in practice: “integral area of glow”, “total” and “normalized area”, “average brightness of spectrum”, “total density”, as well as “fractality” and form coefficient”.

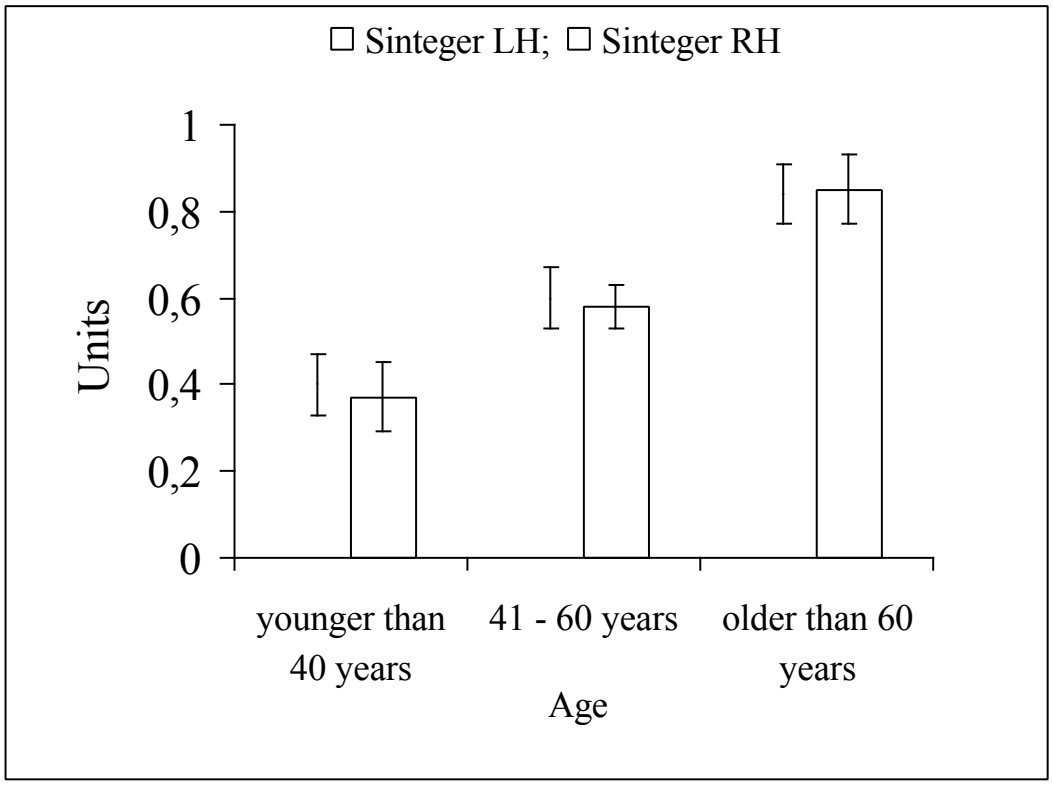

Fig. 1. Distribution of JS parameter for the left (LH) and right (RH) hands in different age categories (processing mode “no filter”)

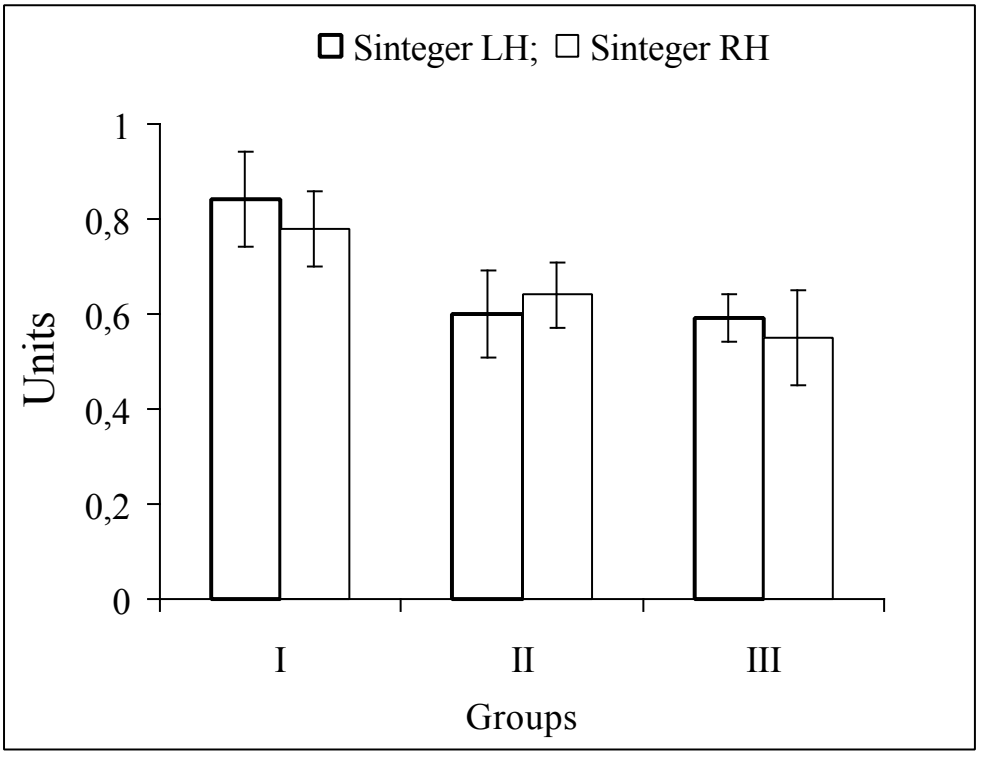

Fig. 2. The differences of JS parameter in the groups depending on the severity of functional state (LH – left hand, RH – right hand) (mode of registration: «without filter»)

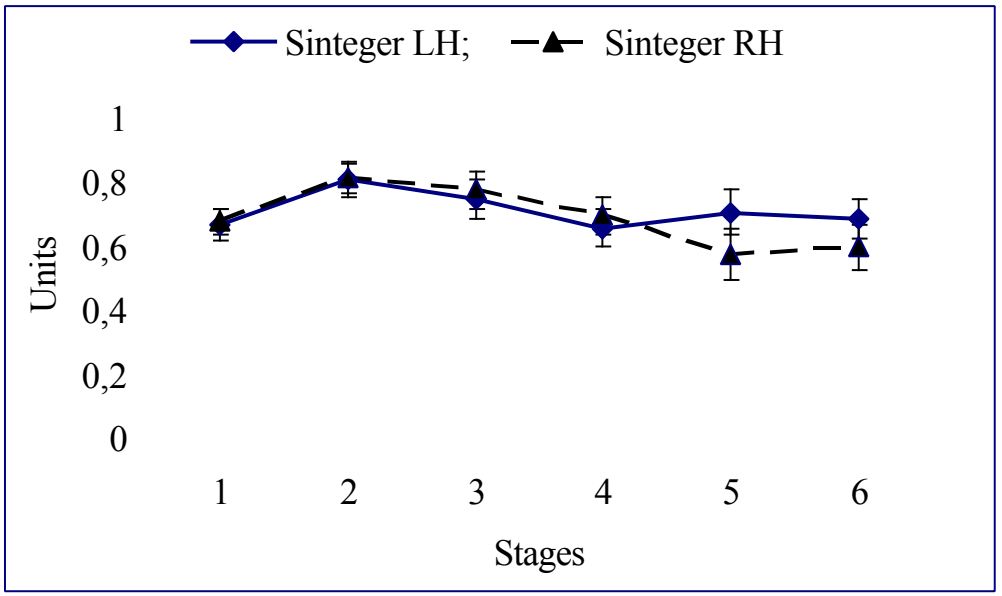

Fig. 3. Trend of JS index of GDV-grams in early postoperative period (LH – left hand, RH – right hand) (registration mode: “without filter”)

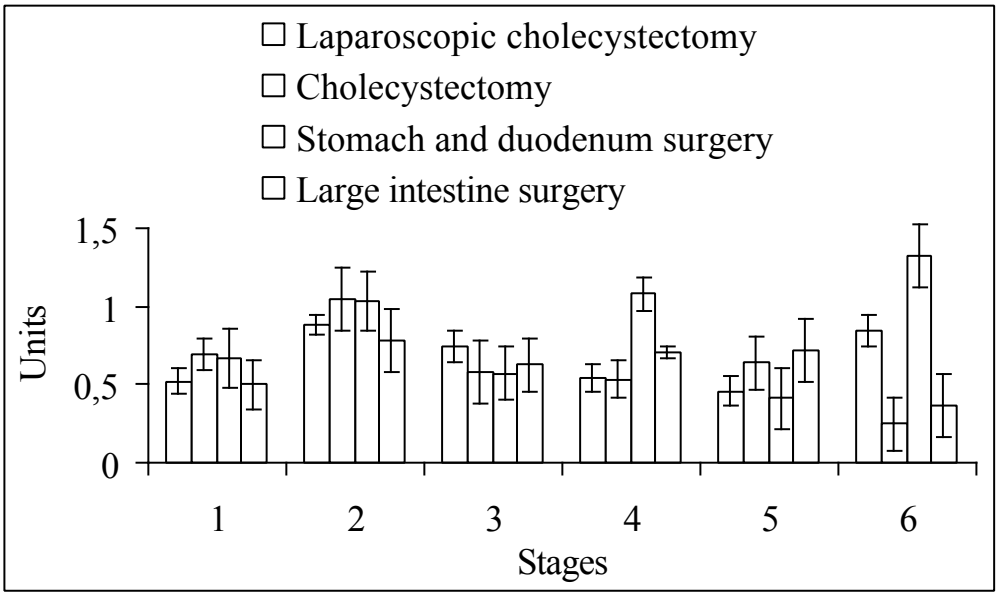

Fig. 4. The dynamics of JS index for the right hand in postoperative period after different surgeries for patients of II group (registration mode: “without filter”)

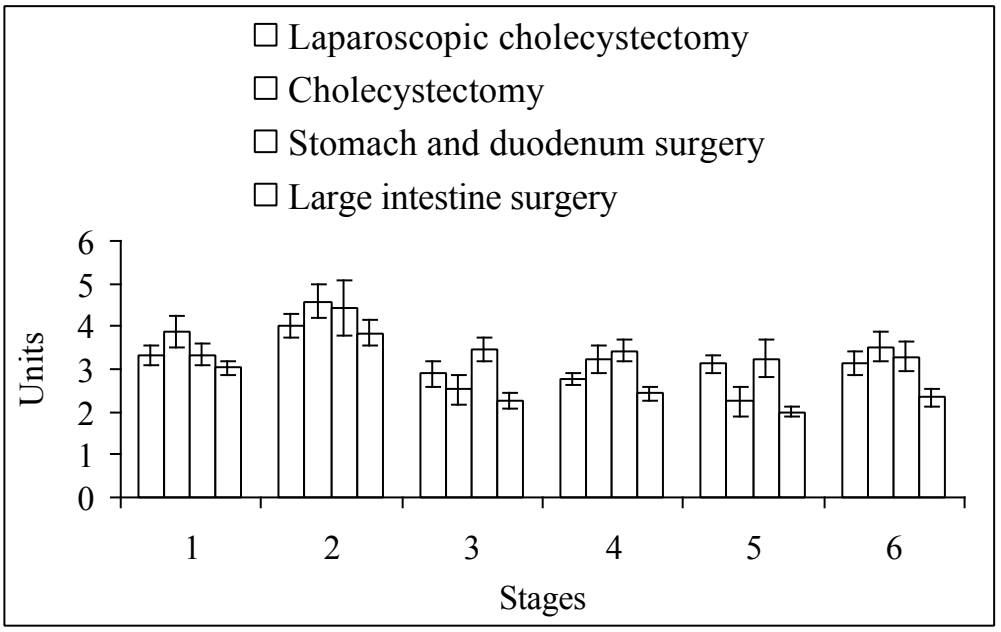

Fig. 5. The dynamics of "normalized area" parameter for the right hand in postoperative period after different surgeries for patients of II group (registration mode: "without filter")

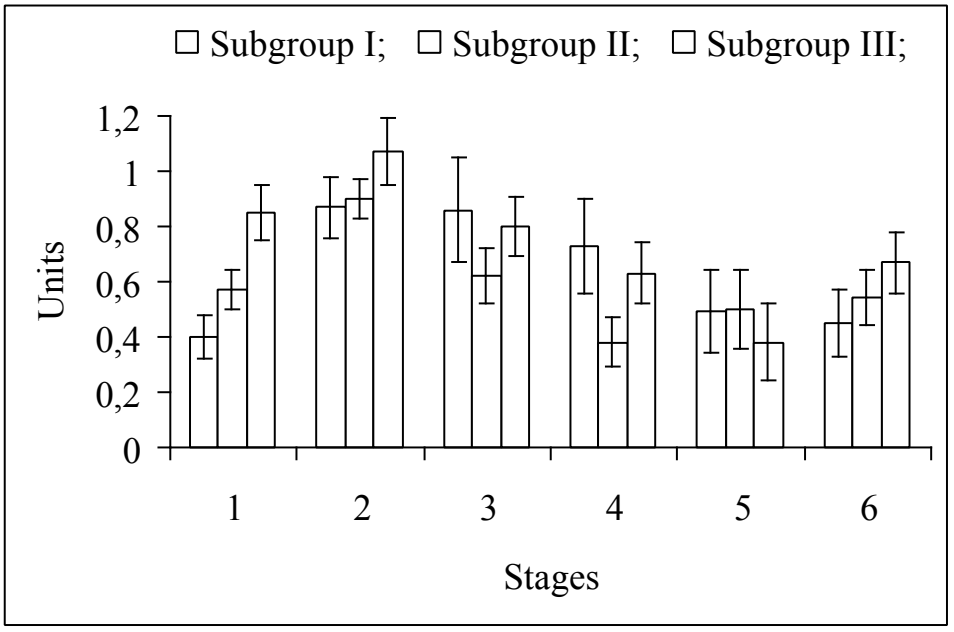

Fig. 6. The dynamics of JS index for the right hand after laparoscopic cholecystectomies (registration mode: "without filter").

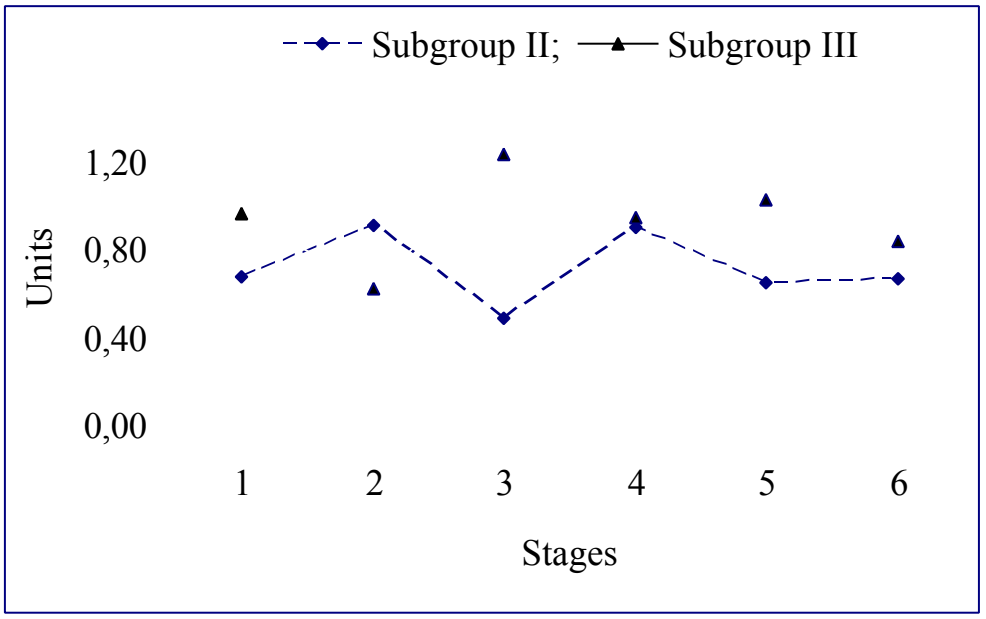

Fig. 7. The dynamics of JS for the right hand for patients after abdominal surgeries (registration mode: “without filter”)

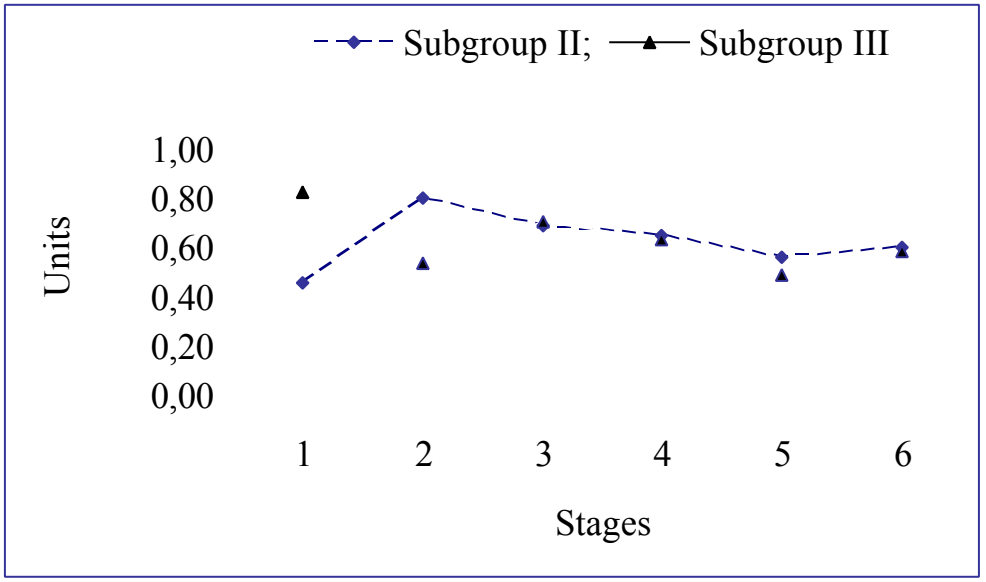

Fig. 8. The dynamics of JS index for the right hand after large intestine surgeries (registration mode: “without filter”)