Chapter 2
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Results of Research on Identifying Patients with Colon Neoplasias with Gas Discharge Visualization Technique

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ABSTRACT

Objective: Initial assessment of the potential of using the Gas Discharge Visualization (GDV) technique to identify patients with colon neoplasia.
Materials and Methods: The group of medical doctors used the Gas Discharge Visualization (GDV) camera to assess subjects with different epithelial lesions. A colonoscopy was performed on each of the 132 subjects, followed by a GDV scan. An endoscopic examination identified colon epithelial lesions 77 patients. The control group consisted of remaining 55 people without lesions. The age of the subjects ranged from 17 to 85 years (mean 64.6 ± 1.2). The study analyzed GDV images of each subject's finger and separate sectors corresponding to the organs in question.
Results: There were a significant number of differences between the control group and the group of patients with colon tumors. We examined the dynamics of the parameters as the level of tumor dysplasia (neoplasia) varied. The values of the following parameters: normalized luminescence area, internal noise, contour radius, and average luminescence intensity - decrease in the control group as compared to patients with cancerous polyps. The values of the following parameters: radius of the inscribed circle, contour line length, area of luminescence, contour line fractality, contour line entropy, form coefficients – increased by comparison.
Conclusion: This pilot study demonstrated a statistical difference between the GDV parameters of patients with colon tumors and the control group.

Keywords: Cancer; electromagnetic fields; energy; research; oncology.

1. INTRODUCTION

According to the International Agency for Cancer Research, colon lesions rank third for incidence rate and rank fourth globally for the number of deaths [1]. Overall, the lifetime risk of developing colorectal cancer (CRC) is about 1 in 20 (5%). CRC is responsible for more than 50,000 deaths every year [2]. In Russia, for all types of cancer, colorectal cancer ranks third and second for the death rate. Further, in 2011, the prevalence of malignant colon neoplasms was 200 cases per 100,000 people [3]. Even though over 50% of all cancer cases are diagnosed in people aged 60 years and older, the disease is increasingly diagnosed at a young age, especially for the patients' families and hereditary forms.

Timely detection of precancerous changes is vital in determining the length of the patient's life and the success or failure of the treatment. Most relevant in the fight against cancer is screening programs for diagnosing diseases at an early stage before developing the classical presentation of the disease. Occult blood tests, often used for mass screening for colorectal cancer, unfortunately, do not have the desired accuracy, sensitivity, and specificity. That is why there has been a growing worldwide focus on finding other non-invasive screening methods. We paid increasing attention to the

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electrophysiological methods and molecular-biological methods, CT-colonography, and video capsule colonoscopy.

1.1 EPI/GDV Technique

Application of computer technology in the processing of electrophysiological information can standardize the procedure, significantly accelerate access to research results, and reduce the influence of subjectivity. Electro-diagnostic techniques, such as Electro-encephalogram and Electrocardiogram, are extensively used in medical practices worldwide. A promising method, already utilized in sixty-two countries to great success, is Electrophotonic Imaging (EPI) based on the Kirlian effect. This effect occurs when an object is placed on a glass plate and stimulated with the current, resulting in the presentation of a visible glow, the gas discharge. The EPI technique allows the recording of electron and photon emission stimulated by an electromagnetic field in any subject, as well as the acquisition of these data by computer image processing. The short electric impulse (10 microseconds) on the camera plate stimulates subjects and generates a response in the form of an excited gas plasma (that is why in physical terms this approach is known as Gas Discharge Visualization – GDV [4-8]). This plasma emits light, which is directly measured by a charge-coupled device (CCD), state of the art in measuring low-level light used in astrophysics and other scientific endeavors. The CCD registers the pattern of photons detected over time. These digital data in the form of graphic files are transmitted directly into a computer for data processing. From these two-dimensional images of the light program calculates the Energy of the emitted photons, area of the image, emission intensity, fracticality, and other parameters. In the latest version of the EPI/GDV technology (www.bio-well.com), programs situated on the server perform all data processing.

Captured images (Bio-grams) of each human subject's ten fingers provide detailed information on the subject's psycho-somatic and physiological state [6-10]. Biofield parameters analysis based on Electrophotonic Imaging (EPI) parameters of finger glow in the electromagnetic field (www.Bio-Well.com, www.IUMAB.club). The EPI technique effectively evaluates the state of individual human health [8-15] and the monitoring of personal reactions to different kinds of training [16-19].

By investigating fluorescent fingertip images, which dynamically change with emotional and physical health states, one can identify congestion or health areas in the whole system. Each generated fingertip photograph is analyzed by sector division, according to acupuncture meridians. Dr. Peter Mandel, in Germany, and Dr. Voll [20], over many decades, have developed this intricate and well-defined method of seeing into the entire body through the fingertips. EPI/GDV technique researchers created a diagnostic table based on years of their own clinical field-testing, the sector basis of which differs slightly from that of Dr. Mandel [5,8].

The image parameters generated from photographing a finger's surface under electrical stimulation create a neurovascular reaction of the skin, influenced by all organs and systems' nervous-humoral status. Due to this, images captured by EPI/GDV register an ever-changing range of states. Besides, most healthy people's EPI/GDV readings vary only 8-10% over many years of measurements, indicating a high level of precision in this technique. Specialized software converts these readings into parameters that elucidate the subject's state of wellbeing at that time.

One of the first studies of cancer diagnosis using GDV was B.L.Horowitz et al. [21]. The study's material was plasma samples of patients with cancer of various organs, both with the absence and the presence of distant metastasis, as compared to blood samples of healthy donors. Results demonstrated that the values of discharge parameters of blood for cancer patients were significantly higher than costs for healthy people for all samples. R.S.Chouhan et al. [22] examined the Bio-grams of fingers of patients in different stages of cervical cancer, showing a significant difference from the image parameters of healthy patients. R. Vepkhvadze et al. [23] by GDV monitoring of patients with squamous cell lung cancer, showed that the results of GDV evaluation and monitoring of the functional status of the patients correlate with clinical, laboratory and instrumental studies in 90-96% of cases. W.Seidov [24] identified some correspondence between GDV parameters and tumors in different parts of the colon.

Our study aimed to investigate the possibility of using the gas discharge visualization technique to identify patients with colon tumors.

2. MATERIALS AND METHODS

The Institutional Review Board approved the consent form according to the guidelines prescribed by the Review Board. All participants were residents of Moscow. The participants of the study were informed that the results would be published in a journal, or used to teach others. The participants were asked to sign the consent form where it was emphasized that their participation was voluntary and that they could withdraw at any time. Before signing the consent form, the participant could refuse to take part in the study (https://bioethicsarchive.georgetown.edu/nbac/clinical/Chap3.htm).

For a group of 132 people, 50 men and 82 women, aged 17 to 85 (mean 64.6 ± 1.2 years). we used the EPI/GDV technology to determine the number, size, localization, and morphology of epithelial lesions of the large intestine. According to the colonoscopy results, the control group included 55 people without polyps; patient's group consisted of 77 patients with epithelial lesions of the colon: 64 patients with benign polyps (hyperplastic polyps - 23; adenomas - 41) and 13 patients with morphologically confirmed colorectal cancer. We did not consider patients with multiple neoplasms in different parts of the large intestine, so 21 patients had neoplasms in the right side of the colon, 34 patients - in the left side; 34 patients had single benign neoplasms, 30 had multiple neoplasms. In 25 patients, the size of neoplasms did not exceed 5 mm; in 34 patients, it was in the range from 6 to 10 mm, and in 5 patients, it was in the range from 11 to 25 mm.

Computer analyses of Bio-grams were performed using the GDV-based "Bio-Well" device (www.bio-well.com). Groups were tested for normality using the Kolmogorov-Smirnov test and the presence of differences using U-criterion Manna-Whitney ($p<0,05$) with the "SPSS Statistics 17.0» program.

In accordance with the principles of Traditional Chinese Medicine, acupuncture channels correlated with the state of the different parts of the colon are located at the Left and right index fingers. In accordance with these principles, GDV software calculates parameters of the particular sectors of the GDV image, corresponding to different parts of the colon system. Both the whole images of the index fingers (Fig. 1) and sectors correlated to the colon system: caecum, ascending, transverse colon, descending, sigmoid colon, rectum; as well as the parts of the spine, which are relevant to the innervation of the colon: lumbar department, sacrum, and coccyx, were studied, for a total of 216 indicators.

The following parameters of GDV-grams were found to be significant (Fig. 1):

Area. A number of light quanta generated by the subject in computer units - pixels (the number of pixels in the image having brightness above the threshold).

Normalized area. The ratio of BEO-gram area to the area of the inner oval.

Intensity. Averaged Energy of light emission in computer units.

Inner radius. The radius of the circle inscribed in the inner oval.

Entropy coefficient. The ratio of BEO-gram external contour to the internal contour.

Form Coefficient is calculated according to the formula: F.C. = Q = k*L2/S, where L is the length of the BEO-gram external contour and S is the BEO-gram area.

Inner noise. Amount of light in the inner oval.

Length of the image contour.

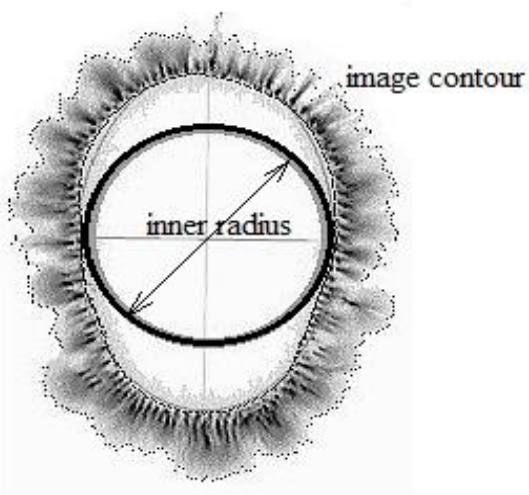

Fig. 1. GDV image (Bio-gram) of a finger with some indicated parameters

3. RESULTS

In accordance with the first objective of our assessment, the differences between the control group and all patients with epithelial lesions of the colon were revealed. Statistically significant differences ($p < 0.05$) had 76 of 216 indicators, 21 of which had a very high level of significance ($p < 0.001$).

The differentiating parameters are the radius of the inscribed circle, normalized area, percentage of internal noise, and shape form characterizing the irregularity of the outer contour of the Bio-grams.

Differences were largely found for the sectors "transverse colon" and "ascending colon." This can be explained by the fact that the majority of the surveyed patients had pathological changes in these parts of the colon. Table 1 shows the averaged values of the parameters and their relative frequency of occurrence between all significant parameters in different studied groups with an increase in the degree of tumor neoplasia.

Table 1. Patterns of change in the parameters of the study groups with increasing degree of tumor neoplasia (average values) (* p <0.01, ** p <0.001)

Parameter	Control	Polyp	Cancer
Control > Polyp > Cancer			
Normalized Area	1.41 ± 0.12	1.27 ± 0.06*	1.09 ± 0.04**
Inner noise	40.90 ± 3.00	31.11 ± 2.51*	23.32 ± 2.01*
Isoline radius	14.21 ± 0.45	11.46 ± 0.32*	10.45 ± 0.42*
Intensity	86.65 ± 0.12	78.04 ± 0.08*	75.19 ± 0.05*
Control < Polyp < Cancer			
Inner circle radius	46.05 ± 1.53	54.45 ± 1.63*	59.37 ± 1.04*
Form Coefficient	11.14 ± 0.54	17.46 ± 0.60*	20.52 ± 0.45**
Isoline fractality	1.60 ± 0.02	1.63± 0.04*	1.71 ± 0.01*
Isoline entropy	1.57 ± 0.03	1.65± 0.02*	1.74 ± 0.01*
Isoline length	950 ± 27	1025 ± 16*	1105 ± 40*
Area	9620 ± 225	10760 ±21*	11427 ± 11*

As one can see from Table 1, parameters have different tendencies in the line Control => Polyp => Cancer. The collection of a larger database of specific cases will allow us to use these parameters to create a mathematical model to distinguish different groups. In order to evaluate the effectiveness of

using the EPI method for the detection of neoplasms of the colon, 69 of the most significant parameters for the pathogenesis of the colon tumors were selected using T-student criterion. Stepwise discriminant analysis in the SPSS Statistics 17.0 package was then carried out using data of patients with neoplasms of the colon and the control group.

Included in the result of stepwise discriminant function analysis were the most significant parameters affecting the assignment of patients to one group or another. Namely, the parameters associated with the descending colon, lumbar, sacrum and coccyx.
The equation consisted of 7 variables (Table 2):

I2L - average intensity of the sector of the descending colon of the index finger of the left hand.

I2LCo - average intensity of the coccyx sector of the index finger of the left hand.

S2Lsac - size in pixels of the sacrum sector of the index finger of the left hand.

I2Lsac - average intensity of the sacrum sector of the index finger of the left hand.

R2RLumb - radius of the inscribed circle of the lumbar sector of the index finger of the right hand.

S2Rsac - size in pixels of the sacrum sector of the index finger of the right hand.

F2Rsac - form factor of the sacrum sector of the index finger of the right hand.

Table 2. The coefficients of the canonical Fisher's linear discriminant functions

	I2Lav	I2LCo	S2Lsac	I2Lsac	R2RLumb	S2Rsac	F2Rsac	Constant
Control	.630	.598	-.015	.501	1.108	.006	.490	-94.303
Cancer	.722	.530	-.009	.407	1.173	.009	.566	-102.081

a. Cross validation is done only for cases in the analysis. In cross validation, each case is classified by the functions derived from all cases other than that case.
b. 83.9% of original grouped cases were classified correctly.
c. 77.4% of cross-validated grouped cases were classified correctly.

As we see from the classification matrix of Table 3, the specificity of the resulting function, after cross verification, is 78.2%, and the sensitivity is 76.8%. We can conclude from these data that the separation between sick and healthy individuals has a fairly high level of precision for screening studies.

We decided, for comparison, to determine the sensitivity and specificity of the method using logistic regression. To achieve this goal the same 69 most significant parameters for the pathogenesis of tumors of the colon that were previously selected using T-student criterion were taken. The values of sensitivity and specificity were calculated at Step 6 as 76.4% and 85.0% respectively (see Table 4).

In conclusion, the dynamics of GDV parameters in the development of the disease was traced. We have found the same tendency as demonstrated in Table 1: values of the radius of the inscribed circle, contour length, form coefficient, and area increased, while the normalized area and the percentage of internal noise were reduced.

Parameters presented in Table 1 characteristic for the whole image of the index finger averaged on the right and left hand. The same tendency we've found for the specific sectors related to the colon system. Fig. 2 presents a comparison of the Inner Circle Radius parameter for different sectors ($p < 0.05$). Fig. 2 presents comparison of Inner circle radius parameter for different sectors ($p < 0.05$).

Table 3. The classification results obtained by using discriminant analysis

	Original				Cross-validated			
	Count		%		Count		%	
	Specificity	Sensitivity	Specificity	Sensitivity	Specificity	Sensitivity	Specificity	Sensitivity
Control	47	14	85.5	17.1	43	19	78.2	23.2
Cancer	8	68	14.5	82.9	12	63	21.8	76.8

Table 4. The classification results obtained using binary logistic regression

	Control/Patients		%%	Control/Patients		%%	Control/Patients		%%
	Specificity	Sensitivity		Specificity	Sensitivity		Specificity	Sensitivity	
	Step 1			Step 2			Step 3		
Control	33	15		33	14		36	16	
Cancer	22	65		22	66		19	64	
Correct %%	60.0	81.3	72.6	60.0	82.5	73.3	65.5	80.0	74.1
	Step 4			Step 5			Step 6		
Control	38	10		39	14		42	12	
Cancer	17	70		16	66		13	68	
Correct %%	69.1	87.5	80.0	70.9	82.5	77.8	76.4	85.0	81.5

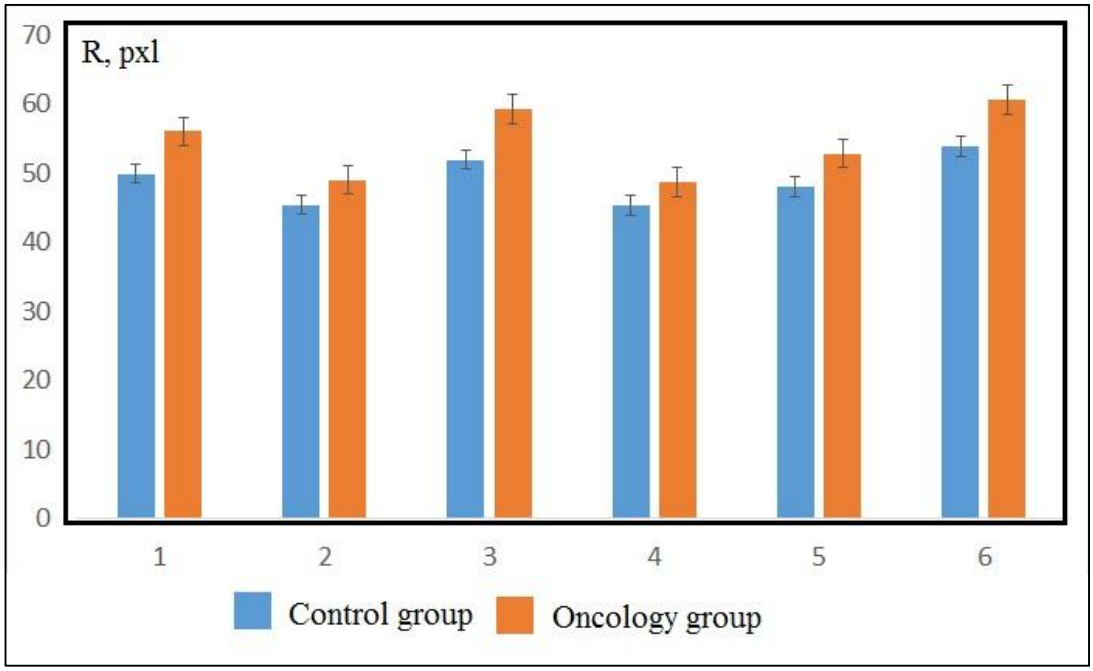

Fig. 2. Comparison of the Inner Circle Radius parameter for different sectors: 1 – whole image; 2 – ascending colon; 3 – a transverse colon; 4 – descending colon; 5 – a sigmoid colon; 6 – rectum

4. DISCUSSION

We compared these obtained results with those of other screening methods used to diagnose colon tumors. The most well-known screening test - FOBT – is the detection of a small amount of occult blood in the intestinal contents. It is performed at home for 3 days, during which it is necessary to follow a diet without animal protein. Another method of occult blood detection - fecal immunochemical test (FIT), is more convenient and does not require a special diet for its production as fewer stool samples are needed. According to Kronborg O., et al. [25], “the key for early detection of polyps and colon cancer is an organization of screening of people older than 50 years for occult blood in the stool and endoscopic examination of persons with a positive result of this analysis; this approach ultimately reduces mortality from colorectal cancer by 15-33%”. However, this method cannot be reliably used in the presence of hemorrhoids. According to [26] “the sensitivity of various noninvasive diagnostic methods for detection of the colon polyps ranges from 30 to 95%”. However, these methods miss the small and flat, e.g. sessile serrated, non-bleeding lesions. Often they produce false-positive and false-negative results. Colonoscopy screening is referred to as the gold standard in some countries. Colonoscopy allows inspecting the whole colon and removing detected polyps. However, “the method is time consuming, rather expensive, requires bowel preparation, it is unpleasant for the patients” [27]. Virtual colonoscopy avoids some of the disadvantages of traditional colonoscopy. The sensitivity of this method in the diagnosis of polyps larger than 10 mm is 90%, while 80% for polyps of 5-9 mm in size, and 67% when the size of the polyp does not exceed 5 mm. Specificity of the method depends on the size of the tumors [28]. However, along with the advantages, the virtual colonoscopy method has significant shortcomings, such as financial inaccessibility and inability to conduct a biopsy and polypectomy, which allows standard colonoscopy. With EPI technology we obtained sensitivity from 74% to 85%, and specificity from 66% to 77%. Thus, the results have proven the ability to identify patients with tumors of the colon using EPI technology, as well as use it for differential diagnosis of tumors of the colon by their morphology, size and quantity. Of course, this is only a preliminary study and much research is needed to find a reliable method for detecting colon tumors using the EPI technique. We need to point out that EPI testing in non-invasive, takes less than five minutes, and the

equipment is relatively cheap and accessible. This opens up good prospects for further research for Electrophotonic Imaging analysis implementation as a first step of the screening process.

When comparing the results of decision rules obtained by using discriminant analysis and binary logistic regression, it should be noted that the specificity of the second rule is somewhat lower (78.2% compared to 76.4%), but the sensitivity is much higher (76.8% and 85.0%). This suggests that although the first is a little better at revealing healthy people, the possibility of identifying the really sick people among the surveyed is significantly higher using logistic regression. It should be noted that among the 7 factors included in the discriminant function, and 6 included in the logistic regression equation, 5 are the same, which confirms the high quality of the obtained functions.

We have performed a statistical analysis of GDV parameters for 7495 people whose data is stored in our database; a varied population ranging from 18 to 100 years old, both men and women, most generally healthy, with some having chronic diseases. Data obtained in this study was not included. Fig. 3 shows a histogram of the radius of the Inner Circle Distribution. Vertical lines denote the averaged value and standard deviations. This range may be accepted as typical parameters for generally healthy people. An arrow indicates the range of parameters for colon cancer. As we see, this range is clearly distinguishable from the norm band, which confirms the validity of the obtained data.

At the same time, we need to point out that these high values of the radius indices may be specific not only for cancer but for other health issues as well. Further research will demonstrate whether it would be possible to distinguish cancer based on multiple GDV parameters.

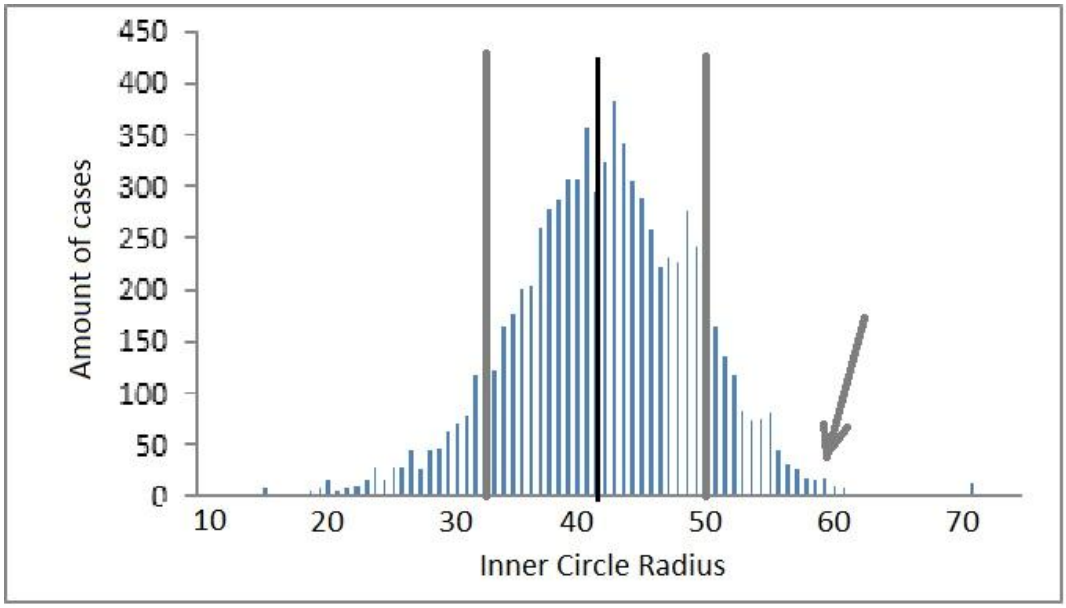

Fig. 3. Histogram of the radius of the Inner Circle Distribution based on an analysis of 10,000 patients

The stage of neoplasia correlates with decreased intensity of luminescence. Further, decreasing percentages of internal noise characterize the level of scattered biophotons radiating from the skin. The lower the activity of physiological systems, the weaker the biophotonic radiation. The value of the parameter Normalized Area, which reflects the extent of adaptation of the organism, decreases as well. The smaller this value is, the less bodily resources for adaptation. As the stages of neoplasia progress, entropy increases; this reflects the balance of regulation. So it can be argued that the distinguished regularities of the GDV parameters dynamically reflect a feature of the physiological systems of the body.

Table 5. Characteristics of different methods of non-invasive diagnosis of colon polyps [26]

Method	Sensitivity	Specificity
Gemokkult test	30,95	80,17
Immunochemical test	37,68	88,76
Erythrocyte sedimentation rate	43,48	78,99

5. CONCLUSION

The pilot study showed the feasibility of using the GDV technique to identify patients with colon epithelial lesions. The main distinguishable parameters for all groups were: the radius of the inscribed circle, normalized area, percentage of internal noise, and form coefficient. These initial positive results encourage the consideration for more in-depth and detailed studies of GDV, with the potential of eventual use in screening programs.

This paper presents the pilot study developing methodological approach to the GDV data processing. That is why we tried different methods of data processing. At the same time we do not pretend to develop a diagnostic method – sample size is too small for this, and other cancer types were not studied. Further research is needed.

COMPETING INTERESTS

Authors have declared that no competing interests exist.

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