UDC:616.34-002.2-008.6-07:613.2-056.25.

Bioimpedance analysis in the assessment of nutritional status and comparative characteristic of the methods of determining nutritional deficiencies in patients with chronic inflammatory bowel diseases.

Stepanov Yu.,
Professor of Interval Medicine, MD, PhD. The Institute of Gastroenterology, NAMS of Ukraine, Director.
Titova M.,
graduate student department bowel disease, State Institution "Institute of Gastroenterology of the National Academy of Medical Sciences of Ukraine", Dnipro, Ukraine. ORCID: https://orcid.org/0000-0001-5182-2635
e-mail: titovamarichka@gmail.com.
Stoikevych M.,
PhD, Heads of the department of intestinal diseases, SI «Institute of Gastroenterology of the National Academy of Medical Sciences of Ukraine», Dnipro, Ukraine. ORCID: http://orcid.org/0000-0002-6111-7267.
e-mail: stoykevich.marina@gmail.com

Resume.

Actuality. Chronic inflammatory bowel disease (IBD) occupies one of the most important positions in the structure of diseases of the gastrointestinal tract in terms of severity, frequency of complications and mortality worldwide. Nutritional status disorders, which are common in patients with IBD, affect the severity of the disease, the development of complications and the overall prognosis, and are an independent prognostic factor in the number of hospitalizations and mortality of these patients. This determines the importance of timely detection and correction of these violations. There are a number of tools used to assess the characteristics of nutritional status. This study will focus on the method of determining the component composition of the body (bioimpedancemetry) and comparing other methods of assessing nutritional deficiency in relation to it to assess what is a more useful tool in clinical settings to diagnose this condition in this category of patients.

The aim of the study: to assess the nutritional status of patients with IBD using bioimpedance analysis; to conduct a comparative analysis of methods for determining nutritional insufficiency.

Materials and methods. We examined 100 patients with IBD, aged from 19 to 79 years, on average (42.54 ± 1.50) years, including 70 patients with UC, 30 - with CD. According to the degree of nutritional insufficiency (detected by caliperometry), all patients were divided into 3 groups (64 patients - without signs of nutritional insufficiency; 24 - with mild and 12 - with moderate nutritional insufficiency). All patients underwent: general clinical examination, anthropometric measurements, general and biochemical blood tests (with determination of total protein, albumin, prealbumin), determination of the level of retinol-binding protein (RBP) by ELISA, and the questionnaire "Nutritional risk screening" (ESPEN recommendations - 2002), bioimpedance analysis (BIA).

Results. According to the results of BIA, by the deviation from the norm of the percentage of fat mass (%FM), it was found that 80% of patients had deviations from normal values, both in the direction of decrease (68% of patients) and increase (12%), which indicates a high frequency of nutritional status disorders in patients with IBD. It was found that the prevalence of nutritional insufficiency in CD is 1.3 times higher than in UC (61.4% - in UC, 83.3% - in CD). Decreased body cell mass (BCM) more commonly revealed in patients with CD, which indicates the development of protein deficiency. Correlation analysis showed that a decrease in the percentage of skeletal muscle mass (% SMM) occurred with age ($r = 0.46$, $p < 0.001$), and was more commonly detected in men ($r = 0.68$, $p < 0.001$). It was found that with increasing severity of nutritional insufficiency there is a probable decrease in BCM ($p < 0,05$). The direct dependence of the fat-free mass (FFM) ($r = 0.33$, $p < 0.05$), % BCM ($r = 0.46$, $p < 0.05$) on the proportion of body fat. The content of total body fluid in patients with IBD with increasing fat in body ($r = 0.53$, $p < 0.05$).

The highest sensitivity, specificity and accuracy of the method (77.9%, 65.6% and 74.0%, respectively) relative to BIA, was found in a complex method, using an integrated evaluation system NRS 2002 in combination with biochemical parameters of protein metabolism, revealed by the comparative analysis. This allows us to consider it as an alternative method of determining malnutrition in hospitalized patients.

Conclusions. BIA is an important tool in detecting nutritional deficiencies in patients with IBD. The closest to it, as showed the statistical analysis, was a complex method using an integrated evaluation system NRS 2002 in combination with biochemical parameters of protein metabolism, so it is possible to recommend its implementation in clinical practice at the hospital stage. The possibility of

applying these methods in a complex will allow a more careful and personalized approach to the definition of nutritional status disorders in this category of patients.

Key words: bioimpedancemetry, nutritional status, chronic inflammatory bowel disease, retinol-binding protein, prealbumin, NRS - 2002.

Introduction. Chronic inflammatory bowel disease (IBD), the main representatives of which are ulcerative colitis (UC) and Crohn's disease (CD), remain one of the unresolved problems of modern gastroenterology and coloproctology [1]. Although both nosological forms are well differentiated by clinical and morphological features, they have insufficiently studied etiology and pathogenesis. The occurrence of an abnormal reaction of the immune system in genetically predisposed patients, which is caused by environmental factors, which causes chronic and uncontrolled inflammation of the intestine is common to both diseases [2]. The nutritional status disorders and underweight (and sometimes, even severe exhaustion in case of untimely detection) as a result of these diseases, significantly affects the course of the underlying disease and worsens its prognosis [3, 4].

The mechanisms underlying nutritional deficiencies in IBD include decreased food intake, impaired nutrient absorption, loss of nutrients with frequent bowel movements, increased energy requirements due to systemic inflammation, and sometimes iatrogenic factors (related to drugs and surgery). At the same time, with the development of malnutrition, the exacerbation phase of the disease is prolonged, increases its severity, the frequency of infectious complications increases due to the development of secondary immunodeficiency. Assessment of nutritional status and the need for supportive dietary therapy play a crucial role in the clinical care of patients with IBD [5, 6].

The malnutrition is common in patients with IBD and ranges from 12% to 85%; this wide range is the result of heterogeneity of groups in relation to nosological forms of the disease, the spread of the inflammatory process and its activity, as well as the variety of methods for assessing this condition [7]. Particularly characteristic is weight loss in patients with CD (65–75%), which is due to the involvement in the pathological process of any part of the gastrointestinal tract and, mainly, the small intestine [8].

A whole set of instrumental and clinical-laboratory methods is used to diagnose malnutrition: somatometric (measurement of body weight, shoulder circumference, thickness of skin and fat folds), laboratory (determination of total protein and albumin levels in blood plasma, absolute number of lymphocytes in the blood), and

also methods for assessing the component composition of the organism [9, 10, 11]. In addition, integrated evaluation systems have been actively introduced into clinical practice, which, combining several parameters, allow to determine the current nutritional status of the patient. The European Society of Clinical Nutrition and Metabolism (ESPEN) recommends the use of the Nutritional Risk Screening System (NRS 2002) to assess nutritional status [12, 13, 14].

The study of the component composition of the body is used both to assess the current state of nutrition of the patient and for its dynamic control during treatment. The need to use methods for assessing the component composition of the body is due to the fact that only somatometric and laboratory parameters do not allow to fully diagnose existing eating disorders. For example, a separate calculation of body mass index (BMI) does not allow to assess changes in the component composition of the body, as focusing only on weight-growth indicators can give a false idea of the amount of fat in the body in case of skeletal muscle atrophy (due to age or hypodynamics). electrolyte balance (with edema), with developed muscles (in athletes). When measuring the thickness of skin and fat folds, visceral adipose tissue is not taken into account, which is an important energy depot in the body, participates in the regulation of physiological and metabolic processes. The normal fat content is a condition for maintaining good health, well-being and efficiency [15]. Assessment of protein metabolism is also important in the study of nutritional status, as the development of protein-energy deficiency and sarcopenia is a common manifestation in patients with IBD [5,13]. Thus, the diagnosis of nutrition should be in complex, involving various assessment methods, including anthropometric and laboratory indicators, the use of integrated assessment systems and assessment of body composition.

In practice, currently the most widely used three methods for assessing the component composition of the body: caliperometry, bioimpedance analysis (BIA) and dual-energy X-ray absorptiometry (DXA). Absorbtiometry and bioimpedancemetry are considered the gold standard for measuring body composition [16, 17]. A limitation for the widespread use of the DXA method is the high cost of the device for this study.

The bioimpedance (BIA) is a widely used method of assessing body composition in clinical practice and research. Bioimpedance analysis is a contact method of measuring the electrical conductivity of biological tissues, which makes it possible to assess a wide range of morphological and physiological parameters of the organism. The list of body composition parameters evaluated by bioimpedance analysis includes absolute and relative indicators. Depending on the measurement

methods, the absolute values are determined both for the whole body and for its individual segments. Absolute indicators include fat mass and fat-free mass (FM, FFM), body cell mass (BCM) and skeletal muscle mass (SMM), total body water (TBW), intracellular water (ICW) and extracellular water (ECW). Along with them, relative (reduced to body weight, lean body mass or other values) indicators of body composition are calculated. Relative indicators are used to compare patients and groups of patients, including those who differ in gender, age, physique and health status [15, 16,].

The aim of the study: to assess the nutritional status of patients with IBD using bioimpedance analysis; to conduct a comparative analysis of methods for determining nutritional insufficiency.

Materials and methods: We examined 100 patients with IBD, aged from 19 to 79 years, on average (42.54 ± 1.5) years, including 70 patients with UC, 30 - with CD. According to the degree of nutritional insufficiency (detected by caliperometry), all patients were divided into 3 groups (64 patients without signs of nutritional insufficiency; 24 - with mild and 12 - with moderate nutritional insufficiency). The inclusion of patients in the study was carried out regardless of the presence or absence of external signs of nutritional status. The assessment of the component state of the body composition of patients was performed using a bioimpedance analyzer of "MEDASS" company. All patients also underwent:

• general clinical examination,

• anthropometric measurements with determination of height and weight indicators and calculation of BMI according to the formula: BMI = m / h2, (where: m - body weight in kilograms; h - height in meters).

• caliperometry with measurement of the triceps skinfold thickness (TSF), Mid-upper arm circumference (MUAC) and calculation of The Mid-Arm Muscle Circumference (MAMC), which was calculated by the formula:

MAMC = MUAC-3.14 x TSF

The TSF was measured in millimeters with a caliper, MUAC was measured in centimeters at the level of the middle third (midway between the tip of the acromial process of the scapula and the ulnar process of the ulna) of the non-working unstressed hand.

• general and biochemical blood tests (with determination of total protein (TB), albumin, prealbumin), study of the level of retinol-binding protein (RBP) was performed by ELISA.

• calculation of the prognostic index of malnutrition (PIM) by the formula:

PIM = 140 - 1,5 (A) - 1 (MUAC) - 0,5 (TSF) - 20 (L),

where: A is the content of blood albumin (g / l); MUAC - mid-upper arm circumference (cm); TSF - triceps skinfold thickness (mm); L- is the absolute number of lymphocytes (10^9 / l). The absolute content of peripheral blood lymphocytes was determined by the formula: total leukocyte count (10^9 / l) × lymphocyte content (%) / 100.

At PIM less than 20 signs of insufficient food are absent (there is no nutrition violation). At values from 20 to 30 is determined by hypotrophy of mild degree, from 30 to 50 - moderate, above 50 - severe [18].

• Application of the integrated assessment system Nutritional Risk Screening NRS-2002, which consists of 3 blocks: 1-initial assessment (BMI, probable weight loss, malnutrition, patient's condition (severity); 2- nutritional status and severity of the disease (more detailed consideration) conditions of weight loss and severity of the patient); 3- degree of nutritional insufficiency (assessment of laboratory parameters: albumin, total protein, lymphocytes, body weight deficit, BMI), and to the third block passed when the sum of points for the first two was 3 and more.

Statistical analysis of the results was performed using Excel Microsoft Office 2010 and SPSS 9.0 for Windows. Comparison of the mean values of the variables was performed using the Mann-Whitney U-test. The statistical significance of the difference was estimated to be at least 95.0% (probability of error $p < 0.05$). Correlation analysis was performed using the Pearson correlation coefficient.

All measuring equipment used in the work were metrologically verified in the prescribed manner.

Research results and their discussion.

According to the results of bioimpedasmetry, namely the deviation from the norm of the percentage of body fat (% of FM), it was found that only 20% of patients had nutritional status within normal limits, while 68% of patients had low nutritional status, in addition to 47 % of patients in the general group already had exhaustion. Elevated trophological status was found in 12% of patients (Fig. 1).

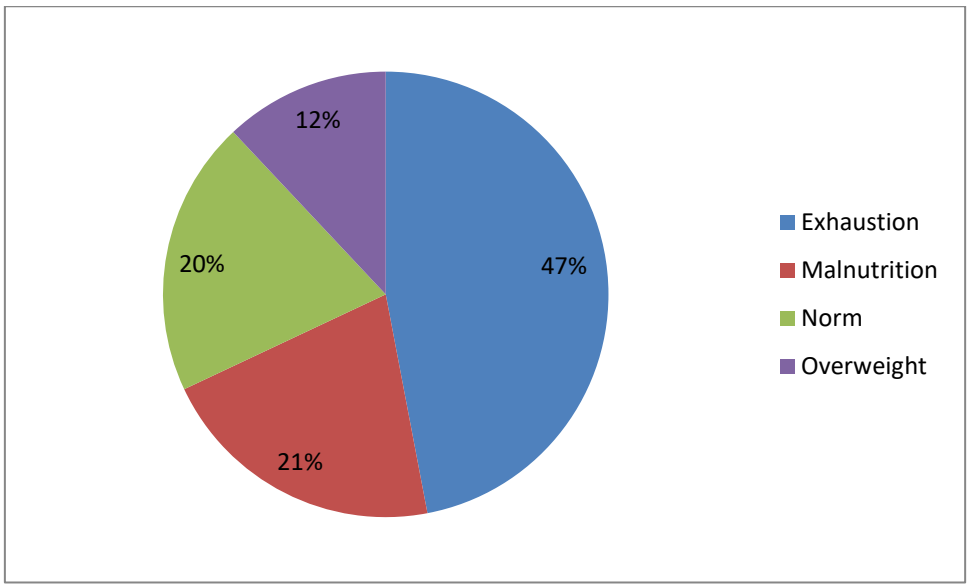
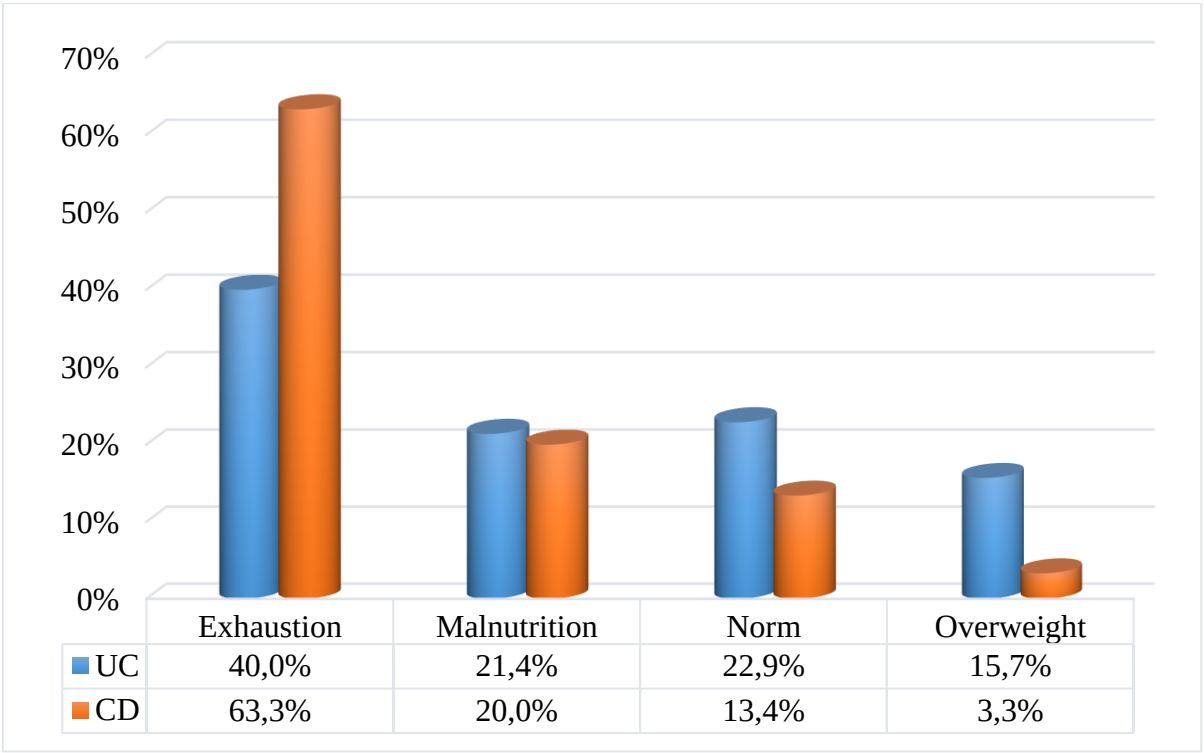


Fig. 1. Nutritional status of patients with IBD by definition of mass fraction of fat.

Peculiarities of% of FM and determination of nutritional status depending on the nosological form in the studied patients are shown in Fig. 2.



	Exhaustion	Malnutrition	Norm	Overweight
UC	40,0%	21,4%	22,9%	15,7%
CD	63,3%	20,0%	13,4%	3,3%

Figure 2. Nutritional status according to the results of bioimpedancemetry (% of FM) in patients with UC and CD.

The predominance of patients with reduced trophological status was observed in both nosologies. However, it was found that in CD the prevalence of nutritional insufficiency is 1.3 times higher than in UC (61.4% - in UC, 83.3% - in CD), which may be due to the depth of the lesion of the intestinal wall and frequent

involvement in the pathological process of small intestine, which complicates the absorption of nutrients. The increase in the percentage of body fat in patients had a positive correlation with BMI ($r = 0.69$, $p < 0.001$).

It should be noted that the absolute indicators of the body composition obtained by bioimpedancemetry have individual normal values for each patient depending on his anthropometric, gender and age characteristics. Therefore, to study the component body composition of the studied patients, depending on the nosology and the degree of nutritional insufficiency (determined by anthropometric indicators), we analyzed relative indicators, such as the ratio of patients to the average value of their norm (percentage of norm) (Tables 1, 3) and the proportion of body components from FFM (percentage of FFM) (Tables 2, 4).

Table 1 - Indicators of the component composition of the body in the studied patients depending on the nosology (percentage of normal).

Indicator	IBD (n=100)	UC (n=70)	CD (n=30)
FM	97,24±53,22	103,47±55,47	82,7±45,14
% of FM	73,53±27,7	77,25±28,63	64,83±23,7*
FFM	98,47±13,55	99,37±14,47	96,36±11,05
BCM	100,67±15,63	102,41±15,63	96,6±15,12
% of BCM	98,74±12,60	98,81±14,11	98,56±8,27
SMM	103,77±14,78	104,57±15,28	101,9±13,63
% of SMM	102,18±5,86	101,9±5,99	102,83±5,57

Note. * - data are plausible ($p < 0.05$) when compared between groups of patients with UC and CD.

As can be seen from the above data, the main changes in the body of patients occurred precisely due to FM. Thus, in the general group of patients the% of FM was lower than normal by 26.5%, while in patients with CD this figure was probably lower than in patients with UC (64.83% vs. 77.25%, respectively) ($p < 0.05$).

Table 2 - Indicators of the component composition of the body in the studied patients depending on the nosology (percentage of FFM)

Indicator	IBD (n=100)	UC (n=70)	CD (n=30)
% of FM	17,41±7,56	18,62±7,95	14,59±5,75*

% of BCM	54,75±4,76	55,04±4,76	54,09±4,78
% of SMM	51,43±4,91	51,16±5,17	52,04±4,27

Note. * - data are plausible (p <0.05) when compared between groups of patients with UC and CD.

A similar probability was obtained when studying the differences between% of FM and FFM: 14.59% in CD versus 18.62% in UC (p <0.05). There was also a tendency to reduce BCM in patients with CD, which indicates the development of protein deficiency. As for the average relative indicators of FFM, BCM, SMM, no significant deviations from the norm and the difference between nosologies were detected. However, in the analysis of individual indicators it was found that in 7 (10%) patients with UC and 6 (20.0%) with CD there was a decrease in the% of BCM. It is known that BCM characterizes the content of metabolically active tissues in the body, and a decrease in this indicator indicates a lack of protein components [19]. In 3 (4.2%) patients with UC there was a decrease in the% SMM - an indicator that characterizes physical development, the decrease of which indicates insufficient development of skeletal muscles, possibly due to hypodynamics or increased catabolic processes. Correlation analysis showed that the decrease in muscle mass in the examined patients occurred with age (r = 0.46, p <0.001), and is more common in men (r = 0.68, p <0.001).

Table 3 - Indicators of the component composition of the body in the studied patients depending on the degree of nutritional insufficiency (percentage of normal).

Indicator	Norm	Mild malnutrition	Average malnutrition
FM	118,48±53,13	61,04±27,25*	56,33±21,65*
% of FM	86,04±24,22	53,20±20,52*	47,41±11,36*
FFM	99,45±15,07	97,62±10,66	94,91±9,63
BCM	102,17±15,37	101,54±15,13	90,91±15,77**
% of BCM	98,81±12,97	100,91±12,32	94,0±10,59
SMM	102,98±15,19	104,75±13,45	106,0±15,9
% of SMM	100,67±5,07	104,04±5,67	106,5±7,29

Notes. * - data are reliable (p <0.0001) when compared with a group of patients without nutritional insufficiency; ** - data are plausible (p <0.05) when compared with a group of patients without nutritional insufficiency.

The study of the components of the body composition in patients with IBD depending on the degree of nutritional insufficiency allowed to establish probable differences between the groups of patients in terms of FM and its share of FFM (p <0.0001). In addition, there was a tendency to decrease the content of FFM and probably lower indicators of BCM, compared with the group of patients without

nutritional deficiency, which indicates a decrease in metabolic-active tissues with increasing severity of nutritional deficiency ($p < 0.05$). These data are confirmed by the established direct dependence of the content of FFM ($r = 0.33$, $p < 0.05$), the % of BCM ($r = 0.46$, $p < 0.05$) on the proportion of body fat.

Table 4 - Indicators of the component composition of the body in the studied patients depending on the degree of nutritional insufficiency (percentage of FFM).

Indicator	Norm (n=64)	Mild malnutrition (n=24)	Average malnutrition (n=12)
% of FM	20,62±6,88	12,35±5,57	10,44±3,12*
% of BCM	54,71±4,2	56,17±4,98	52,18±6,28
% of SMM	50,26±4,43	52,66±4,72	55,19±5,61**

Notes. * - data are reliable ($p < 0.0001$) when compared with a group of patients without nutritional insufficiency; ** - data are plausible ($p < 0.05$) when compared with a group of patients without nutritional insufficiency.

Another important component of body composition, which primarily determines homeostasis, and hence the functioning of life support systems, is the total body water. Normally, total body water (TBW) is about 55% of body weight in women and 60% - in men, the share of intracellular water (ICW) is 60% of TBW, the remaining 40% is extracellular water (ECW) . In patients with IBD, the need to assess the state of hydration and fluid distribution in the body is an urgent issue, as indicators of homeostasis determine the effectiveness of ongoing therapy and predict the course of the disease.

The analysis of the volume and distribution of fluid in the body of patients with IBD is given in table.

Table 5 - Average indicators of water sectors of the body (percentage of normal) in patients with IBD depending on the nosology.

Indicator of BIA	IBD	UC	CD
TBW	99,03±11,95	100,1±12,2	96,40±11,06
ECW	304,3±87,8	302,5±93,8	308,5±73,5
ICW	14,73±7,04	15,16±7,46	13,72±5,92

It was found that in most of the subjects there was a redistribution of fluid due to an increase of more than 2.5 times the ECW and a decrease in ICW. This indicates an increase in the permeability of cell membranes against the background of the inflammatory process. In the analysis of indicators of water sectors of the body of the examined patients depending on the nosological form, no significant

differences were found, but there is a tendency that in patients with CD is more pronounced redistribution of fluid due to increased ECW, which may be due to more common inflammatory process in any part of the gastrointestinal tract.

Depending on the nutritional status (Table 6), it was found that TBW was within normal limits in all patients with preserved trophological status and in most patients with its violation. But the average values of TBW were probably higher - (114.25 ± 10.01)% in patients with high nutritional status compared with patients with its decrease - (97.44 ± 11.26)% ($p < 0.0001$), which indicates a tendency to fluid retention in patients of this group and is confirmed by the obtained direct correlation between the content of TBW and% of FM ($r = 0.53$, $p < 0.05$).

Table 6. The average indicators of the water sectors of the body (percentage of normal) in patients with IBD depending on the nutritional status determined by the BIA method.

BIA indicator	Nutritional status		
	reduced	norm	increased
TBW	97,44±11,26	95,32±8,29	114,25±10,01*
ECW	301,36±86,64	300,2±106,33	327,41±59,26
ICW	8,231±14,583	7,223±16,034	5,293±11,694

Note. * - data are plausible ($p < 0.0001$) when compared with groups of patients with reduced trophostatus.

For a more detailed assessment of the state of nutritional status, we additionally used anthropometric and laboratory research methods, which are also considered to be highly informative indicators of malnutrition [20].

Thus, the determination of growth and weight indicators and the calculation of BMI revealed 20% of patients with IBD with a decrease in this indicator, which indicated malnutrition.

The method of caliperometry, with the measurement of TSF, MUAC and calculation of MAMC, with the help of special tables allowed to identify 36% of patients with IBD (of the general group) with nutritional insufficiency.

Analysis of the results of the calculation of PIM revealed 53.0% of patients with malnutrition of varying degrees.

The use of an integrated assessment system "Nutritional Risk Screening" (NRS 2002) in combination with the assessment of additional more sensitive indicators of the visceral pool of protein (namely prealbumin (PA) and retinol-binding protein (RPB) [21, 22]) revealed 66.0% of patients with nutritional insufficiency.

We also conducted a detailed comparative analysis of indicators obtained by different methods of assessing nutritional status depending on the nosological form and the degree of nutritional insufficiency (table 7).

Table 7. Indicators of nutritional status depending on the nosological form and the degree of nutritional insufficiency.

Indicators of nutritional status	The degree of nutritional insufficiency						Norm
	light			average			
	UC	CD	p	UC	CD	p	
BMI(kg/м^2)	21,72±3,03	18,73±1,99	**0,011**	19,85±1,96	17,94±1,02	0,05	19–25
MUAC (см)	23,35±1,08*	23,50±1,17	0,761	20,82±0,75	20,02±2,11	0,155	26–29
TSF (см)	0,914±0,141	0,782±0,162	**0,046**	0,784±0,093	0,612±0,241	0,157	0,95–0,1
MAMC (см)	20,48±1,12**	21,05±1,0#	0,218	18,27±0,74	18,06±0,41	0,395	23–26,7
TP (g/l)	63,85±6,66	65,73±10,4	0,601	67,16±8,99	57,66±6,12	0,05	≥ 65
A (g/l)	34,77±6,06	30,35±2,84	**0,041**	32,42±2,87	30,03±2,92	0,186	≥ 36
PA (g/l)	0,243±0,062##	0,292±0,084	0,108	0,232±0,043	0,271±0,083	0,183	≥0,3
RPB (ng/ml)	18,93±5,094	12,08±4,57	**0,003**	18,28±5,71	8,824±0,663	**0,011**	≥21,4
PIM	27,64±21,32	33,63±11,48	0,431	29,54±24,92	44,39±12,94	0,225	≤20

Notes. * - data are plausible ($p < 0.001$) when compared with a group of patients with moderate degree of nutritional insufficiency; ** - data are plausible ($p < 0.005$) when compared with a group of patients with moderate nutritional insufficiency; # - data are plausible ($p < 0.001$) when compared with a group of CD patients with moderate nutritional deficiency; ## - data are plausible ($p < 0.01$) when compared with a group of UC patients with moderate nutritional deficiency.

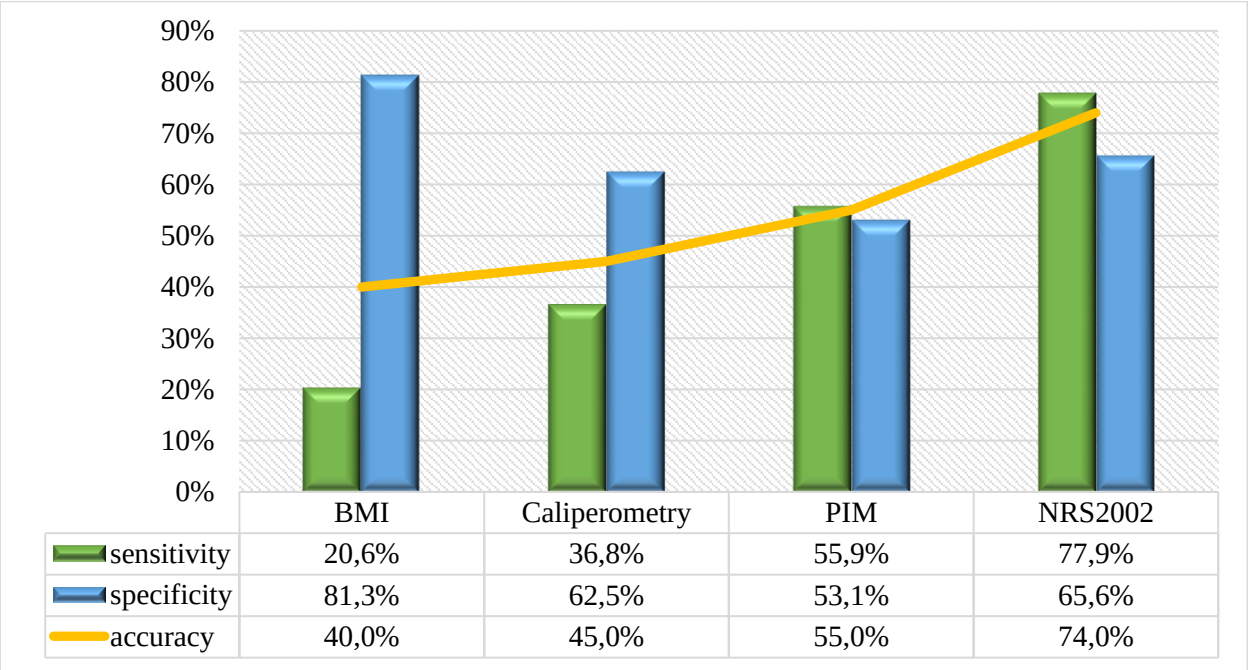
Discussion

Thus, the BMI in mild malnutrition was significantly lower in patients with CD compared to patients with UC - 18.7 ± 1.99 kg / m2 vs. 21.72 ± 3.03 kg / m2, respectively (p = 0.011). The same trend was observed at the average severity of malnutrition - 19.85 ± 1.96 kg / m2 in patients with UC against 17.9 ± 1.02 kg / m2, but the data did not have a significant difference.

Analyzing the data obtained when measuring TSF, MUAC, MAMC, a decrease in all indicators below the norm was noted, which indicated, first of all, a decrease in the somatic pool of protein. It should be noted that these changes were more characteristic of patients with CD, as evidenced by a significant difference in TSF between nosological forms in the group with an average degree of malnutrition - 0.91 ± 0.14 cm in patients with UC against 0.78 ± 0.16 cm in patients with CD (p = 0.046). The average value of MAMC in patients with UC with an average degree of malnutrition was 18.27 ± 0.74 cm, which is 20.6% below normal, and in patients with CD –18.06 ± 0.41 cm, which is 21, 4% below normal. According to the literature, the deviation of the MAMC from the norm by more than 10% is quite informative to assess malnutrition, which indicates the severity of muscle proteolysis and reduced adaptive reserves of the body [23].

Assessing the biochemical parameters of protein metabolism (TP, albumin, PA, RBP), which characterize the visceral pool of protein, all patients showed mild hypoalbuminemia. The albumin is known to be a more sensitive marker of protein deficiency than total protein, but less sensitive than PA and RBP [21,22]. The concentration of PA in the blood was reduced and corresponded to the degree of malnutrition in the study groups. RBP levels were reduced in all patients with nutritional insufficiency, but the most pronounced decrease in this indicator was observed in patients with CD - 12.08 ± 4.57 ng / ml in mild malnutrition and 8.82 ± 0.66 ng / ml in severe (which is almost 2.5 times lower than normal). Therefore, these indicators can be considered quite reliable markers of nutritional deficiency in patients with IBD. Indicators of protein metabolism were used in a comprehensive assessment in conjunction with an integrated assessment system "Nutritional Risk Screening" (Nutritional Risk Screening, NRS 2002).

Because the accuracy of the obtained results of BIA is close to the data of high-precision and at the same time expensive study - X-ray densitometry, which is considered the gold standard, in our study we used the BIA method as a reference, and determined diagnostic sensitivity, specificity and accuracy. considering true-negative, false-positive and false-negative results. Diagnostic parameters were determined by the method of constructing a Latin square (Fig. 3).



	BMI	Caliperometry	PIM	NRS2002
sensitivity	20,6%	36,8%	55,9%	77,9%
specificity	81,3%	62,5%	53,1%	65,6%
accuracy	40,0%	45,0%	55,0%	74,0%

Fig. 3. Comparative characteristics of methods for determining of nutritional insufficiency.

Thus, the method of determining of malnutrition by BMI showed the highest specificity (81.3%), but the lowest sensitivity (20.6%), which excludes the possibility of its use in clinical practice for this purpose.

The method of caliperometry alone showed insufficient sensitivity (36.8%) for the determination of malnutrition, but its indicators are used to calculate the PIM, so its use for this purpose is possible only as a supplement to other methods.

The calculation method for determining PIM had a sufficient level of sensitivity and specificity (55.9% and 53.1%, respectively), which makes it possible to use it in the outpatient stages of malnutrition diagnosis.

The greatest sensitivity, specificity and accuracy of the method (77.9%, 65.6% and 74.0%, respectively) was a complex method using an integrated evaluation system NRS 2002 in combination with biochemical parameters of protein metabolism. This makes it possible to consider this method of malnutrition diagnosing at the clinical stage, as an alternative, in the absence of the possibility of using BIA, or other methods of determining the component composition of the body.

Conclusions.

1. The bioimpedancemetry revealed a high frequency of nutritional status disorders in patients with IBD. According to the study, 68% of patients had reduced nutritional status, and 47% already had depletion. Nutritional

insufficiency according to the results of BIA was more common in patients with CD and occurred 1.3 times more often than in UC (61.4% - in UC, 83.3% - in CD).

2. It was found that with increasing severity of nutritional insufficiency there is a probable decrease in BCM ($p < 0,05$). The direct dependence of the content of FFM ($r = 0.33$, $p < 0.05$),% of BCM ($r = 0.46$, $p < 0.05$) on the proportion of fat in the body. The content of TBW in patients with IBD increases with increasing proportion of body fat ($r = 0.53$, $p < 0.05$).
3. Comparative analysis of other methods for determining nutritional deficiency in relation to BIA revealed the highest sensitivity, specificity and accuracy (77.9%, 65.6% and 74.0%, respectively) in the complex method using the integrated assessment system NRS 2002 in combination with biochemical parameters of protein exchange. This allows us to consider it as an alternative method of malnutrition determining in hospitalized patients.

Conflict of interest. The authors declare the absence of a conflict of interest in the preparation of this article.

References:

1. Kaplan GG. The global burden of IBD: from 2015 to 2025. Nat Rev Gastroenterol Hepatol. 2015;12(12):720–727. doi:10.1038/nrgastro.2015.150
2. Nishida A, Inoue R, Inatomi O, Bamba S, Naito Y, Andoh A. Gut microbiota in the pathogenesis of inflammatory bowel disease. Clin J Gastroenterol. 2018;11(1):1–10. doi:10.1007/s12328–017–0813–5
3. Pulley J, Todd A, Flatley C, Begun J. Malnutrition and quality of life among adult inflammatory bowel disease patients. JGH Open. 2019;4(3):454–460. Published 2019 Nov 14. doi:10.1002/jgh3.12278
4. Curtis LJ, Bernier P, Jeejeebhoy K, et al. Costs of hospital malnutrition. Clin Nutr. 2017;36(5):1391–1396. doi:10.1016/j.clnu.2016.09.009].
5. Balestrieri P, Ribolsi M, Guarino MPL, Emerenziani S, Altomare A, Cicala M. Nutritional Aspects in Inflammatory Bowel Diseases. Nutrients. 2020;12(2):372. Published 2020 Jan 31. doi:10.3390/nu12020372
6. Bischoff SC, Escher J, Hébuterne X, et al. ESPEN practical guideline: Clinical Nutrition in inflammatory bowel disease. Clin Nutr. 2020;39(3):632-653. doi:10.1016/j.clnu.2019.11.002
7. Casanova MJ, Chaparro M, Molina B, et al. Prevalence of Malnutrition and Nutritional Characteristics of Patients With Inflammatory Bowel

Disease. J Crohns Colitis. 2017;11(12):1430–1439. doi:10.1093/ecco–jcc/jjx102

8. Sandall AM, Wall CL, Lomer MCE. Nutrition Assessment in Crohn's Disease using Anthropometric, Biochemical, and Dietary Indexes: A Narrative Review. J Acad Nutr Diet. 2020;120(4):624-640. doi:10.1016/j.jand.2019.04.013
9. Gurtsiev M.Kh., Zharikov Yu.O., Alexandrova E.A., Shkerdina M.I., Antonyan S.Zh., Yartsev P.A. Approaches to assessing nutritional status in patients with dysphagia syndrome. *Bashkortostan Medical Journal*. 2020;15(6):136-142. (In Russ.)
10. Back IR, Marcon SS, Gaino NM, Vulcano DSB, Dorna MS, Sassaki LY. Body composition in patients with crohn's disease and ulcerative colitis. Arq Gastroenterol. 2017;54(2):109–114. doi:10.1590/S0004–2803.201700000–02
11. O.I. Kostyukevich, S.V. Sviridov, A.K. Rylova, N.V. Rylova, M.I. Korsunskaya, E.A. Kolesnikova. Malnutrition: from pathogenesis to current methods for diagnosis and treatment. Terapevticheskij arhiv. 2017;89(12–2):216–225. https://doi.org/10.17116/terarkh20178912216-225(In Russ.)
12. Kondrup J, Rasmussen HH, Hamberg O, Stanga Z; Ad Hoc ESPEN Working Group. Nutritional risk screening (NRS 2002): a new method based on an analysis of controlled clinical trials. Clin Nutr. 2003 Jun;22(3):321–36. doi: 10.1016/s0261–5614(02)00214–5. PMID: 12765673.
13. Li S, Ney M, Eslamparast T, et al. Systematic review of nutrition screening and assessment in inflammatory bowel disease. World J Gastroenterol. 2019;25(28):3823–3837. doi:10.3748/wjg.v25.i28.3823
14. Hersberger L, Bargetzi L, Bargetzi A, et al. Nutritional risk screening (NRS 2002) is a strong and modifiable predictor risk score for short–term and long–term clinical outcomes: secondary analysis of a prospective randomised trial. Clin Nutr. 2020;39(9):2720–2729. doi:10.1016/j.clnu.2019.11.041
15. Stepanov Yu.M., Boiko T.Y., Sorochan O.V., Stoikevych M.V., Shkaredna A.S. Bioimpedancemetry in evaluating nutritional status of patients with chronic inflammatory bowel diseases. Gastroenterol.2015;2(56):59–66.
16. Scaldaferri F, Pizzoferrato M, Lopetuso LR, et al. Nutrition and IBD: Malnutrition and/or Sarcopenia? A Practical Guide. *Gastroenterol Res Pract*. 2017;2017:8646495. doi:10.1155/2017/8646495

17. Sergi G, De Rui M, Stubbs B, Veronese N, Manzato E. Measurement of lean body mass using bioelectrical impedance analysis: a consideration of the pros and cons. *Aging Clin Exp Res*. 2017;29(4):591-597. doi:10.1007/s40520-016-0622-6 Lemos T. , Gallagher D. Current body composition measurement techniques. Curr Opin Endocrinol Diabetes Obes. 2017. Vol. 24 (5). P. 310–314. DOI: 10.1097/MED.0000000000000360.
18. Frenchov V G, Khoroshilov I E. The Role of nutritional support in intensive care of patients with acute pancreatitis. Experimental and clinical gastroenterology. 2009; 6: 58-60 (In Russ).
19. Gaivoronskiy IV, Nichiporuk GI, Gaivoronskiy IN, Nichiporuk NG. Bioimpedansometry as a method of the component body structure assessment (review). Vestnik Sankt-Peterburgskogo universiteta. Meditsina. 2017; 12(4): 365-384. https://doi.org/10.21638/11701/spbu11.2017.406 (In Russ).
20. Stepanov Yu., Titova M. Somatometric and biochemical studies in complex assessment of nutritional satus in chronic inflammatory bowel disease. Journal of social sciences, nursing, public health and education. 2021(1) P. 124–132
21. Dağ Z, Köseoğlu H, Kekilli M. The use of prealbumin as a predictor of malnutrition in cirrhotic patients and the effect of nutritional support in patients with low prealbumin levels. Turk J Med Sci. 2020;50(2):398–404. Published 2020 Apr 9. doi:10.3906/sag–1910–27
22. Ingenbleek Y. Plasma Transthyretin as A Biomarker of Sarcopenia in Elderly Subjects. Nutrients. 2019;11(4):895. Published 2019 Apr 21. doi:10.3390/nu11040895
23. Leal Escobar G, Osuna Padilla IA, Cano Escobar KB, Moguel González B, Pérez Grovas HA, Ruiz Ubaldo S. Phase angle and mid arm circumference as predictors of protein energy wasting in renal replacement therapy patients. Ángulo de fase y circunferencia media de brazo como predictores de desgaste proteico energético en pacientes con terapia renal sustitutiva. *Nutr Hosp*. 2019;36(3):633-639. doi:10.20960/nh.