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Magnetic resonance enterocolonography for assessing inflammation activity in Crohn's disease using the CDMI and MEGS indices

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ABSTRACT *AIM: to estimate the diagnostic value of magnetic resonance enterocolonography using inflammation indices (CDMI, MEGS) in assessing activity of the inflammatory process in the large and small intestine in Crohn's disease.*
PATIENTS AND METHODS: the study included 42 patients with Crohn's disease (aged 19–47 years). All patients underwent magnetic resonance enterocolonography (MRE) with intravenous contrast and diffusion-weighted images. According to the results of MRE, the MR indices of inflammation activity in the small and large intestine (CDMI and MEGS) were assessed. The MR inflammatory activity indices CDMI and MEGS were compared with the endoscopic inflammatory activity index SES-CD.
RESULTS: the MR inflammation activity index CDMI did not show a significant diagnostic value ($p > 0.05$), while MEGS showed it ($p < 0.0001$). According to the nomogram, the MEGS demonstrated a high predictive ability to determine the true activity of the inflammatory process in the small and large intestine. Correlation demonstrated direct strong relationship between the quantitative values of the MEGS and SES-CD ($r = 0.843$, $p < 0.0001$).
CONCLUSION: magnetic resonance enterocolonography using the MEGS activity index has a high diagnostic value in assessing the activity of the inflammatory process in the small and large intestine in Crohn's disease. The results of the study should be considered preliminary and require further recruiting for larger sample.

KEYWORDS: *MRI, magnetic resonance enterocolonography, MEGS, CDMI, MR indices of inflammatory process activity, SES-CD*

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INTRODUCTION

Crohn's disease is a non-specific inflammatory lesion of various parts of the gastrointestinal tract of unknown etiology, characterized by segmental intestinal lesion and recurrent course [1]. The most common complications of Crohn's disease are bowel fistula and pericolic abscesses [2]. Treatment for Crohn's disease includes drug therapy and surgery indicated in the presence of complications or ineffectiveness of conservative therapy [2, 3]. Of particular relevance is the assessment of changes in the activity of the inflammatory process in response to ongoing therapy. Currently, one of the most informative methods for assessing the activity of the inflammatory process in the small and large intestine and the effectiveness of drug therapy is colonoscopy [5, 6]. However, endoscopic examination makes it possible to evaluate only intestinal manifestations of Crohn's disease in the large intestine and terminal ileum, and is uninformative for lesions of the jejunum, as well as complications of Crohn's disease (abscesses, intestinal fistulas). This circumstance dictates the urgent need to find new

methods for assessing the severity of the activity of the inflammatory process in the small and large intestine.

Currently, the possibilities and prospects of MR-enterocolonography (MRE) in Crohn's disease are being actively investigated to assess the activity of inflammation in the small and large intestine and the effectiveness of drug therapy [7]. In clinical practice, the assessment of inflammation activity is based on the use of MR semiotics, which is most often subjective. The most promising in MRE is the use of inflammatory activity indices for a more objective analysis of inflammatory activity [8]. Currently, the most well-known and studied indices of inflammation are MaRIA and Clermont, based on the use of intravenous contrast and diffusion-weighted images with high diagnostic value [9–17]. However, these indices of inflammation activity are time-consuming to use and require a highly qualified radiologist, which significantly limits their use in clinical practice. However, there are less studied and easier to analyze indices of inflammation activity (Crohn's Disease Magnetic Resonance Imaging Index (CDMI), Magnetic Resonance Enterography Global Score (MEGS)), also based on a quantitative assessment of inflammation activity [18–24]. Thus, the issue of finding a more effective, convenient in clinical practice MR index of inflammation activity remains relevant, which allows us to reliably assess the activity of inflammation in the small and large intestine in Crohn's disease in order to choose the optimal treatment approach.

AIM

Determination of the diagnostic effectiveness of magnetic resonance enterocolonography using inflammation indices (CDMI, MEGS) in assessing the activity of the inflammatory process in the large and small intestine in Crohn's disease.

PATIENTS AND METHODS

The study included 42 patients with Crohn's disease (age ranged from 19 to 47 years). Seventeen (40.4%) primary patients who had not previously received drug therapy and 25 (59.5%) patients in the process of conservative treatment for Crohn's disease (hormonal, immunosuppressive, biological therapy) were included. Of these, 28 (66.7%) are women and 14 (33.3%) are men.

Patients included in the study underwent total colonoscopy and ileoscopy of the distal part of the ileum.

According to the results of endoscopy, Crohn's disease in the form of colitis and ileocolitis was diagnosed in 26 (61.9%) patients, in 16 (38.1%) patients in the form of terminal ileitis.

The activity of the inflammatory process in the large and small intestine according to endoscopic examination was evaluated according to the endoscopic index of inflammatory activity SES-CD (Simple endoscopic severity for Crohn's disease). The endoscopic index of inflammatory activity was calculated segmentally (separately in each part of the intestine — ileum, ascending colon, transverse colon, descending colon, sigmoid colon, rectum). The activity of the inflammatory process according to the endoscopy was evaluated according to the following criteria: infiltration of the mucosa, hyperemia, hemorrhages and aphthae — related to the moderate activity of the inflammatory process; ulcers corresponded to the pronounced activity of inflammation [23].

Magnetic resonance enterocolonography was performed in the X-Ray Diagnostics, Computer and Magnetic Resonance Imaging Unit of the RNMRC of Coloproctology of the Health Ministry of Russia on a Philips Achieva 1.5Tl tomograph (Netherlands). The preparation of the patients included a slack-free diet for 3 days prior to the study. To contrast the small and large intestine, 60 minutes before the start of the study, patients took Lavacol® *per os* in a volume of 1,000 ml, in small portions every 15–20 minutes. A solution of gadopentetatadimeglumin at a dosage of 0.1 mmol/kg was used for intravenous contrast.

A 16-channel receiving and transmitting coil for the SenseXLTorso body was used.

After the MRE, the CDMI and MEGS inflammatory activity index was calculated.

Table 1. *MR-signs used to calculate the indices of inflammation activity CDMA and MEGS*

MR-sign	Points	Severity of the sign
Thickening of intestinal wall	0	< 3 mm
	1	3–5 mm
	2	5–7 mm
	3	> 7 mm
Signal from the intestinal wall on T2-WI	0	intestinal wall without visible changes
	1	dark gray signal from T2-WI with fat suppression
	2	light gray signal from T2-WI with fat suppression
	3	increased signal from the intestinal wall
The state of pericolic fat	0	No visible changes
	1	Increased signal from pericolic fat, however, without fluid accumulation
	2	Accumulation of liquid with a layer thickness of up to 2 mm
	3	Accumulation of liquid with a layer thickness of 2 mm or more
Intensity of accumulation of contrast agent by the intestinal wall	0	No signs of increased accumulation of contrast agent by the intestinal wall
	1	The intensity of accumulation of contrast agent is significantly lower than the intensity of contrast of the parietal vessel
	2	The intensity of accumulation of contrast agent is slightly lower than the intensity of contrast of the parietal vessel
	3	The intensity of accumulation of the contrast agent corresponds to the intensity of contrast of the parietal vessel
The nature of the accumulation of contrast agent by the intestinal wall	0	No accumulation/ homogeneous accumulation
	1	Accumulation of intestinal mucosa
	2	"layered"/transmural accumulation of contrast
Smoothness of gaustration	0	No
	1	< 1/3 segment
	2	1/3–2/3 segments
	3	> 2/3 segments

The CDMI index (segmental) was calculated for each segment of the intestine: ileum, ascending colon, transverse colon, descending colon, sigmoid colon, rectum according to the formula: CDMI = 1.79 + 1.34 × thickness of the intestinal wall at the lesion site (mm) + 0.94 × points obtained based on changes in the signal from the affected area of the intestinal wall according to T2-WI (Table 1).

The MEGS index (segmental) was also calculated separately for each segment of the intestine: ileum, ascending colon, transverse colon, descending colon, sigmoid colon, rectum according to the ranking of points depending on the MR-sign (Table 1). MEGS (segmental) = the sum of all MR-signs points.

RESULTS

When assessing magnetic resonance enterocolonography, the following MR-signs were evaluated:

Table 2. *Diagnostic value of inflammation indices*

	Logistic coefficient	Standard error	*P*-value
CDMI	–0.0042	0.0502	> 0.05
MEGS	0.2413	0.0464	< 0.0001
			moderate activity < 0.0071 pronounced activity < 0.0001

the thickness of the intestinal wall, the change in the signal from the intestinal wall, the state of pericolic fat, the intensity of accumulation of contrast agent by the intestinal wall, the nature of accumulation of contrast agent, smoothness of gaustration (Fig. 1, 2).

The total sample size included 252 segments of the large intestine and ileum. The segmental

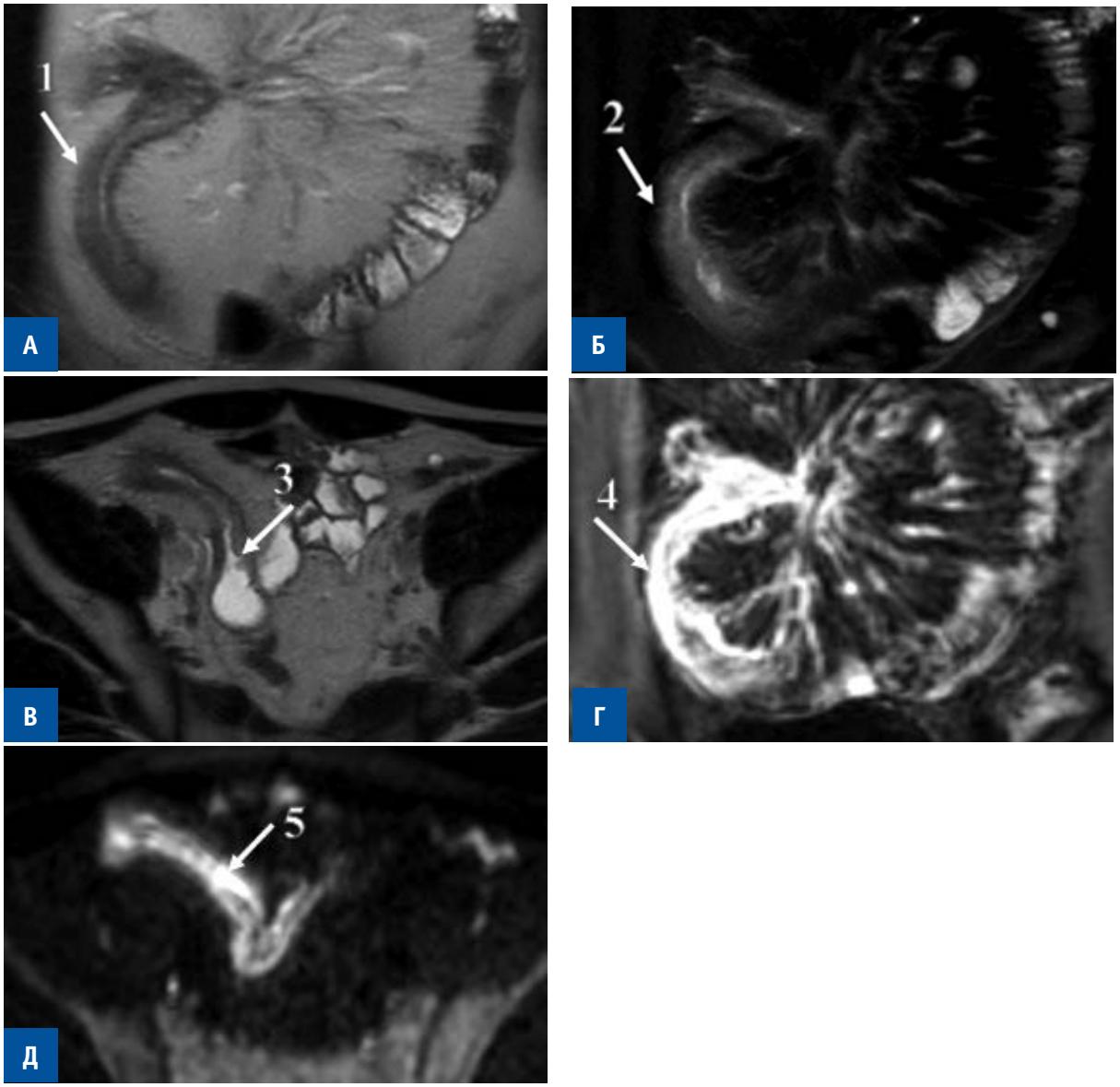


Figure 1. *MRI. Crohn's disease in the form of ileitis. А — T2-weighted image, cor; Б — T2-weighted image with fat suppression, cor; В — T2-weighted image, ax; Г — T1-weighted image with contrast enhancement, cor; Д — diffusion-weighted image, ax. 1 — thickening of the intestinal wall, 2 — edema of the submucosal layer, 3 — ulcerative defect, 4 — transmural accumulation of a contrast agent, 5 — restriction of diffusion from the intestinal wall.*

quantitative index of inflammatory activity (CDMA and MEGS) was compared with the segmental endoscopic index of inflammatory activity SES-CD. According to the colonoscopy data, all segments were divided into 3 groups according to the activity of the inflammatory process: 1 — absence of inflammatory process activity (80 segments), 2 — moderate inflammatory process activity (93 segments), 3 — pronounced inflammatory process activity (79 segments). To analyze the effectiveness of MR indices of inflammation activity in the small and large intestine CDMA and MEGS, the method of ordinal logistic regression was used (Table 2).

The MR index of inflammation activity CDMI did not show significant diagnostic efficacy ($p > 0.05$). The MR index of inflammation activity MEGS showed significant diagnostic efficacy ($p < 0.0001$). It can be assumed that the greater informative value of the MEGS index is associated with a large number of assessed MR-signs, while the CDMI index

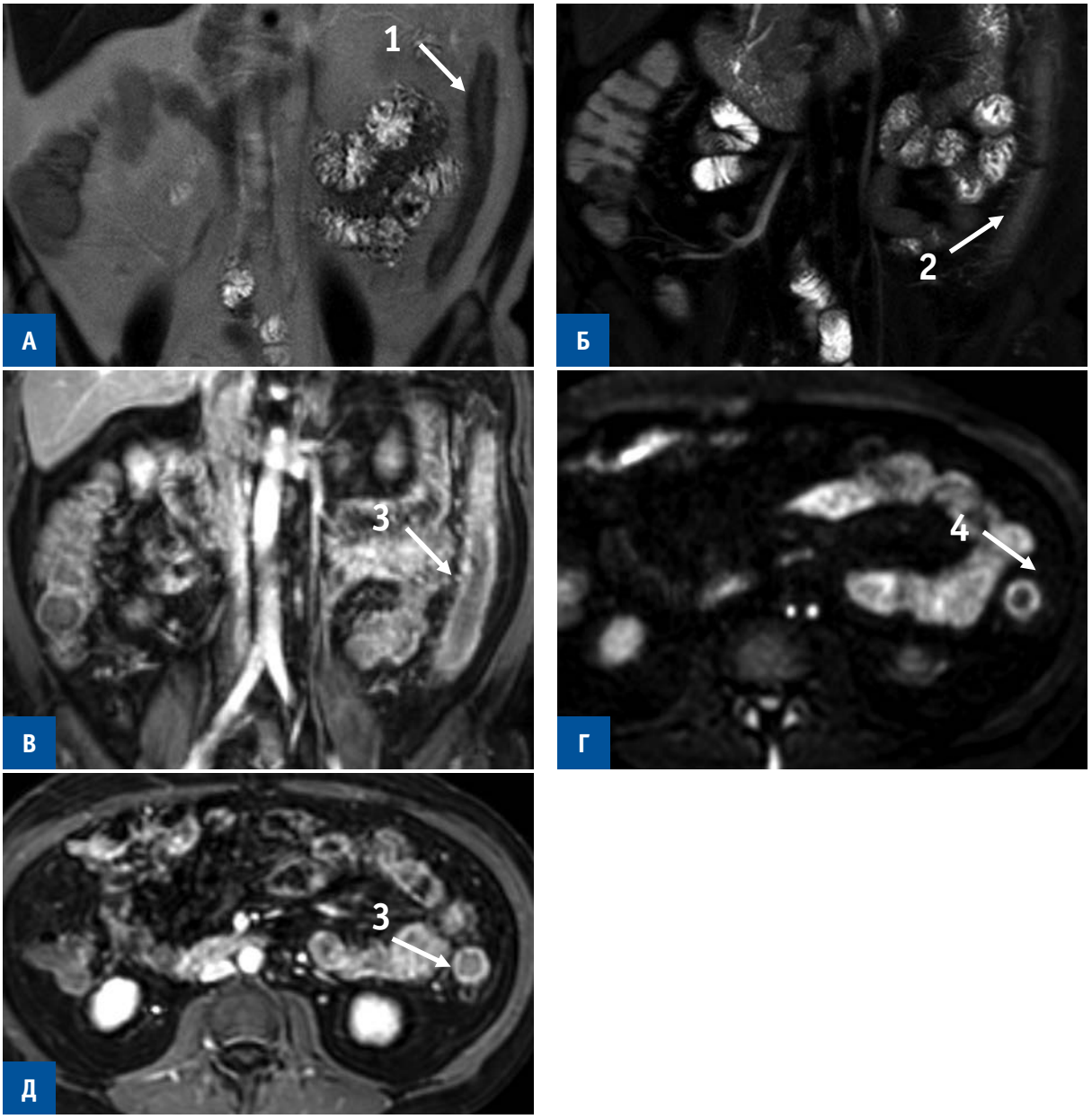


Figure 2. *MRE. Crohn's disease in the form of ileitis. А — T2-weighted image, cor; Б — T2-weighted image with fat suppression, cor; В — T1-weighted image with contrast enhancement, cor; Г — diffusion-weighted image, ax; Д — T1-weighted image with contrast enhancement, ax. 1 — thickening of the intestinal wall, 2 — hypervascularization of the adjacent fiber, 3 — increased accumulation of the contrast agent, 4 — restriction of diffusion from the intestinal wall.*

evaluates only two signs (thickening of the intestinal wall and the nature of changes in the intestinal wall according to MRI data).

Based on the logistic coefficient, a nomogram of the predictive ability of the quantitative indicator of the MR-MEGS index of the true activity of the inflammatory process in the small and large intestine was constructed, which was initially evaluated by colonoscopy. From the results of the nomogram, it follows that with a value of MEGS = 6, the probability that the patient has moderate activity of the inflammatory process is approximately 68%, against which the probability of having a pronounced inflammatory process is 18%. With a value of MEGS = 12, the probability that the patient has moderate activity of the inflammatory process is approximately 90%, the probability that the inflammatory process also has a more pronounced activity of the process is 55%. With a value of MEGS = 16, the probability that the patient has at least moderate activity of the inflammatory process is 95%, and the probability that the inflammatory process has a more pronounced activity of the process is 70%. At this stage of the sample size of patients, the diagnostic model speaks more about the likelihood of a moderate inflammatory process.

When analyzing the correlation between the quantitative values of the MEGS inflammation indices and the endoscopic inflammation index, a direct strong relationship between them was revealed (Fig. 4).

DISCUSSION

Endoscopic examination of the large and small intestine is the gold standard in the diagnosis of Crohn's disease. However, it has a number of limitations: the impossibility of examining more proximal segments of the intestine relative to inflammatory or cicatricial narrowing. Magnetic resonance imaging is a non-invasive method and allows you to visualize the inflammatory process in all parts of the small and large intestine and assess extra-intestinal complications of Crohn's disease, such as: intestinal abscesses and fistulas [12]. MRE has no radiation load for the patient and can be repeatedly performed to assess the dynamics of the inflammatory process against the background of conservative treatment. All of the above makes MRE a promising method for the diagnosis of Crohn's disease and contributes to the search for the most reliable MR-criteria for quantifying the activity of the inflammatory process in the small and large intestine. Currently, MaRIA and Clermont inflammatory activity indices are the most widespread, based on the use of intravenous contrast and diffusion-weighted images and having a fairly high diagnostic value. However, their measurement is laborious and requires a highly qualified radiologist. Currently, less studied and easier to analyze indices of inflammation activity CDMI and MEGS are of interest, which in the future will allow the introduction

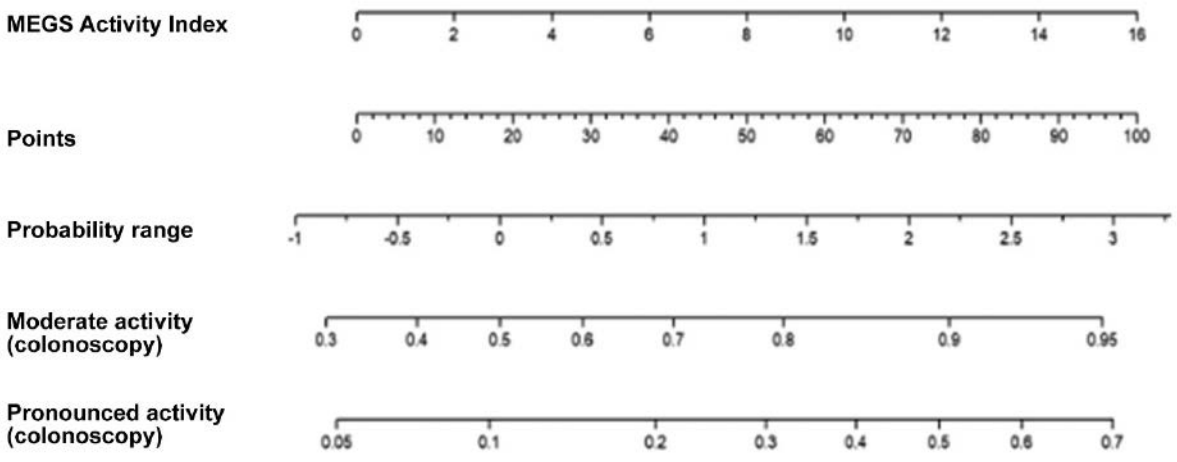


Figure 3. *Nomogram of the predictive ability of the MEGS index*

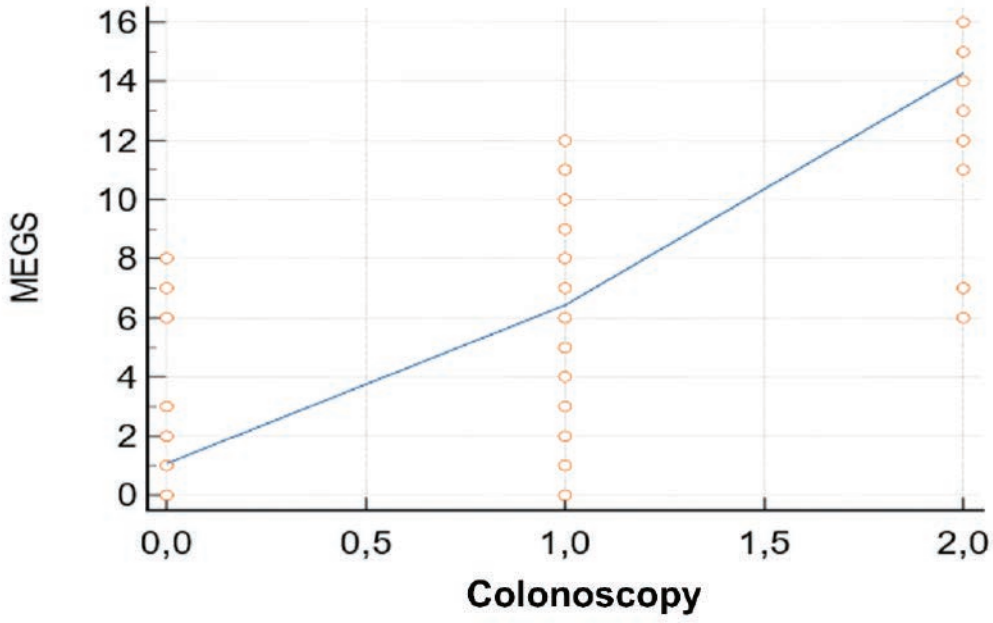
of quantitative assessment of inflammation activity into clinical practice.

In this study, the MR-indices of the inflammatory process CDMI and MEGS were compared with the "gold" standard — endoscopic examination of the small and large intestine. According to the results of our study, the MR-index of inflammation activity CDMI did not show statistically significant diagnostic efficacy ($p > 0.05$), which is probably due to a small number of estimated MR-signs (thickness of the intestinal wall and the nature of the change in the signal of the intestinal wall on T2-weighted images).

The MEGS MR-index of inflammatory activity showed statistically significant diagnostic efficacy ($p < 0.0001$).

The constructed nomogram of the predictive ability of the quantitative indicator of the MEGS MR-index demonstrated a good diagnostic value of the index with moderate activity of the inflammatory process (maximum 95%). The predictive ability in relation to a pronounced inflammatory process was 70% (the maximum value), which is a satisfactory level of diagnostic effectiveness, but requires further improvement by increasing the sample size. Correlation analysis of the MEGS activity index revealed a strong direct correlation with the endoscopic SES-CD inflammation activity index ($r = 0.843$, $p < 0.0001$).

There are isolated scientific publications devoted to the MR- indices of CDMI and MEGS activity. In these studies, the analysis was carried out on a small sample of patients, without attempting to validate the inflammatory process for moderate and pronounced activity, studying only the possibilities of these MR-indices in determining the inflammatory process as a whole. Threshold values for moderate and pronounced activity of



Sample size	252
Spearman's coefficient of rank correlation (rho)	0,843
Significance level	P<0,0001
95% Confidence Interval for rho	0,803 to 0,876

Figure 4. *Diagram. Correlation of the MR index of inflammation and the endoscopic index of inflammation*

the inflammatory process were also not determined [19–24].

In our study, the MEGS activity index demonstrated better diagnostic efficiency compared to CDMI.

The MEGS index includes a greater number of MR-signs (thickness of the intestinal wall, change in the signal from the intestinal wall, the state of pericolic fat, the intensity of accumulation of contrast agent by the intestinal wall, the nature of accumulation of contrast agent, smoothness of gaustration). Each MR-sign, depending on its nature and severity, is assigned a certain number of points. To calculate the MEGS segmental index, it is required to add up all the points for each MR-sign, without the need to use a time-consuming formula, which significantly reduces the analysis time and, in the future, will allow it to be used more extensively in clinical practice. Such MR-indices of inflammation as MaRIA and Clermont in a recent study demonstrated high diagnostic effectiveness, but they are not widely used in practical medicine, due to the complexity of their analysis [17]. Also, given the good correlation with the endoscopic index, MEGS can be used to assess the dynamics of the inflammatory process in the therapeutic treatment of Crohn's disease. However, we consider the data we have obtained preliminary due to the low power of the study, which requires its continuation to determine the optimal MR-index of the activity of the inflammatory process in the small and large intestine.

CONCLUSION

Magnetic resonance enterocolonography using the MEGS activity index has a high diagnostic efficiency in assessing the activity of the inflammatory process in the small and large intestine in Crohn's disease. The MR-index of CDMI inflammation activity did not show statistically significant diagnostic efficacy. The results of the study should be considered preliminary and further study of the possibilities of these indices of inflammation activity in a larger sample of patients is required.

AUTHORS CONTRIBUTION

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