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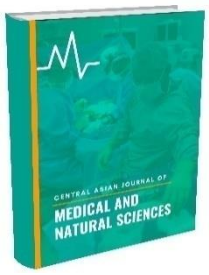

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Transabdominal Ultrasound for Inflammatory and Tumoral Diseases Intestine: New Possibilities in Oral Contrasting with Polyethylene Glycol

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Key words: ultrasound, enteroclysis, ultrasound contrasting of the small and large intestine, inflammatory bowel disease, tumor of the colon.

Abstract: The purpose of the work is to review current data on the possibilities of transabdominal ultrasound (ultrasound) in the diagnosis of intestinal diseases, as well as to present our own results on improving the echographic visualization of the wall of the small and large intestine.

There are the following main options for the technique of transabdominal ultrasound of the intestine: 1) without any special preparation, and the study is best done on an empty stomach, but in emergency gastroenterology, echography after eating is possible; 2) enteroclisis ; 3) contrasting of the small intestine; 4) ultrasonic irrigoscopy ; 5) Ultrasound of the intestine emptied from the contents after cleaning the colon with a solution of polyethylene glycol (PEG) taken orally (as for colonoscopy); 6) contrasting the small and large intestine with a PEG solution taken orally.

The best visualization of the intestinal wall was noted when using a two-stage application of PEG, when half the dose of PEG was taken in the evening, ultrasound was performed in the morning, and then the second half of PEG was taken and ultrasound was performed 30–120 minutes later, depending on the area of interest. The best visualization of the small intestine wall occurs 30-60 minutes after the morning PEG intake. For the diagnosis of exophytic tumors of the colon, it is proposed to perform the above-described technique of ultrasound of the colon approximately 2 hours after the second dose of PEG. Among the methods of radiation imaging, ultrasound should be the 1st line of diagnosis in inflammatory bowel diseases.

Introduction

The possibility of non-invasive imaging of the intestine is not loses its appeal to gastroenterologists. Of course, any beam imaging method does not replace endoscopic examination with biopsy, but there is a number of clinical situations related to both primary diagnosis and evaluation of the effectiveness of treatment, when computed tomography (CT), magnetic resonance imaging (MRI) or conventional radiopaque study intestines can provide important information. In recent years thanks to the improvement of the technical capabilities of the equipment and clinical studies diagnostic capabilities of the ultrasound (US) method are positioned as not inferior to CT and MRI in a number of diseases of the small and large intestine. Echography steadily occupies its diagnostic niche due to the unique possibility of visualizing the intestinal wall. This is of particular importance in inflammatory bowel diseases (IBD) - ulcerative colitis (UC) and Crohn's disease (CD), when it is necessary to assess the dynamics of the inflammatory process and its complications in the course of treatment. It is no coincidence that one of the articles in 2019 in the most authoritative (in terms of impact factor) gastroenterological journal Gastroenterology was entitled: “Intestinal ultrasound: more not the Cinderella of visualization methods." It is noteworthy that along with the key new directions in ultrasound diagnostics (USD) - contrasting, elastography , interventional methods, which have been devoted in recent years to the international recommendations of the European Federation of the Society for Ultrasound in Medicine and Biology (European federation of Societies for Ultrasound in Medicine and Biology - EFSUMB), considerable attention is paid to intestinal echography [6–9]. At the same time, to date, ultrasound examination (ultrasound) of the intestine has not become a routine diagnostic procedure in clinical practice. One of the reasons is the lack of awareness of clinicians and ultrasound specialists about the possibilities of this study. In addition, intestinal ultrasound requires a highly qualified doctor and his many years of experience in ultrasound pathology of the abdominal organs. It is not in vain that the last provision is listed as one of the main ones in the EFSUMB recommendations [6].

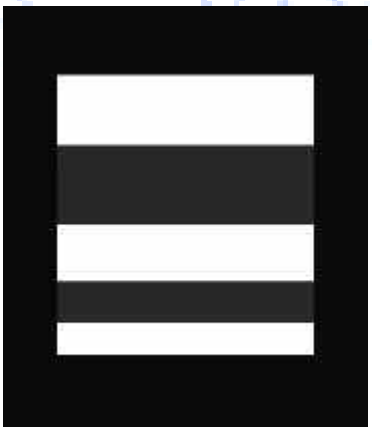
The purpose of the work is to review current data on the possibilities of transabdominal ultrasound in the diagnosis of intestinal diseases, as well as to present our own results on improving the echographic visualization of the walls of the small and large intestine.

Ultrasound technique There are the following main options for the technique of transabdominal ultrasound of the intestine:

1) without any special preparation, and the study is best done on an empty stomach, but in emergency gastroenterology, echography after eating is possible;
2) enteroclisis ;
3) contrasting of the small intestine;
4) Ultrasound irrigoscopy ;
5) Ultrasound of the intestine emptied from the contents after cleaning the colon with a solution of polyethylene glycol (PEG) taken orally (as for colonoscopy);
6) contrasting the small and large intestine with a PEG solution taken orally [2, 10].

For a general examination, a convex probe with a frequency of 3.5–5.0 MHz is used, for a detailed study of the intestinal wall, a linear probe with a frequency of 7.0–15 MHz is used. Normally, the thickness of the intestinal wall does not exceed 2 mm [6]. This rule, first of all, concerns cases of application of the high-frequency sensor. Pathological wall thickness is usually considered to be greater than 3 mm. When using a 3.5–5.0 MHz abdominal convex probe, this pathological limit may be 4 mm. The normal wall of the intestine has a five-layer structure similar to the entire

gastrointestinal tract, in which, counting from the cavity of the organ, a superficial (boundary) echogenic layer is distinguished, then hypoechoic , corresponding to the mucous membrane, then a submucosal layer (echogenic), muscular (hypoechoic) and serous (echogenic); rice. 1. Normally, the shape of the mesenteric lymph nodes (LN) is oval, oblong or U-shaped, echogenicity is low or moderate, the maximum longitudinal size is up to 17 mm, and the transverse size is up to 4 mm [6]. In our experience, visualization of normal or slightly enlarged LNs in apparently healthy people is possible for a long time after bacterial acute intestinal infections. The causes of pathological enlargement of mesenteric LNs are numerous [10]. The maximum diameter of the small intestine in a healthy person does not exceed 2.5 cm. The maximum diameter of the colon is 5 cm [6], but the size of the caecum can exceed this value by 1 cm . conventional transabdominal ultrasound of the abdominal organs on an empty stomach, intestinal echography is most often used in clinical practice. Ultrasound is performed with the patient lying on his back [2, 6]. It is undesirable to conduct a study in the next day after colonoscopy or irrigoscopy . To assess blood flow, the fasting period should be at least 6 hours, to study motility - the night before the study. In emergency gastroenterology, ultrasound is performed regardless of food intake. Suspicion of intestinal obstruction is now the generally accepted indication for ultrasound. In the presence of a tumor or severe inflammation of the intestine, a significant thickening of its wall is determined, which makes it possible to visualize the “symptom of a hollow organ lesion” (HSS), i.e. a peculiar structure with an echoic center and a hypoechoic periphery. The term SPPO was introduced in the Russian-language literature by Z.A. Lemeshko, a similar designation is used abroad as a “symptom pseudobuds ”, “targets” or “cockades” [2, 10–12]. In colon cancer, SPSS is detected locally at the site of the tumor (Fig. 1-3). Usually, in the presence of infiltrative tumor growth, it can be detected in almost all patients with T3-T4 (according to the TNM classification), in about 1/3 of cases - with T2. In the initial stage of cancer (T1), this ultrasound symptom cannot be positive, except in cases of UC, against which colon cancer has developed. SPSS is a non-specific symptom, it is observed not only in cancer, lymphoma and benign tumors of the small and large intestine, but also in case of acute or chronic inflammation of the intestine.



Rice. 1. Schematic representation of the layers of the wall of the gastrointestinal tract.

Note. 1 – superficial (boundary) echogenic layer; 2 - hypoechoic layer corresponding to the mucous membrane; 3 - submucosal layer (echogenic); 4 - muscular (hypoechoic) layer; 5 - serous layer (echogenic); the vertical arrow in the diagram corresponds to the correct determination of the thickness of the intestinal wall.

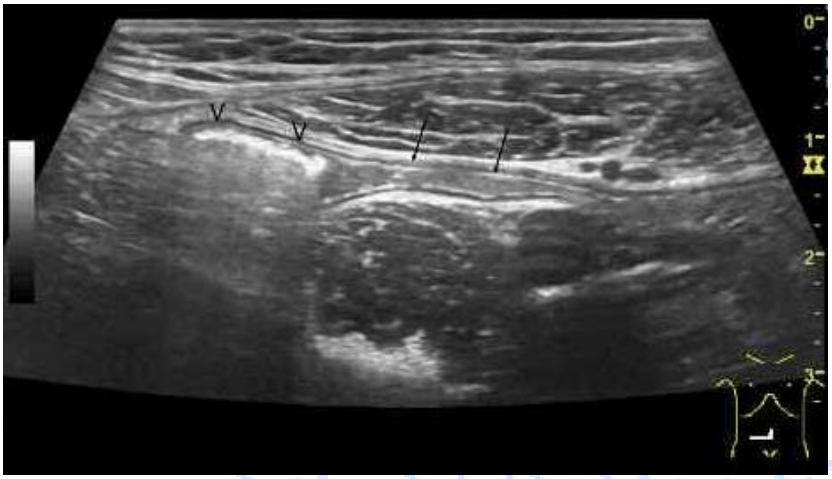
This applies to UC, CD, pseudomembranous colitis, and other cases of inflammatory changes in the intestinal wall, leading to its thickening (see Fig. 1–3) [7, 10]. In UC, the bowel lesion extends proximally (upward) from the rectum, and thickening of the intestinal wall is determined over a considerable extent, reflecting the severity of the disease. A characteristic feature of CD is the segmentation of the bowel lesion and the involvement of the ileocecal region, which is determined by

ultrasound (see Fig. 1-3). The technique and anatomy of ultrasound of the small and large intestine is described in sufficient detail [2]. The small intestine is usually actively peristaltic , in the large intestine real-time peristalsis is imperceptible, haustra and the movement of intestinal contents are visualized. With an ultrasound of the intestine, 3 groups of signs are taken into account:

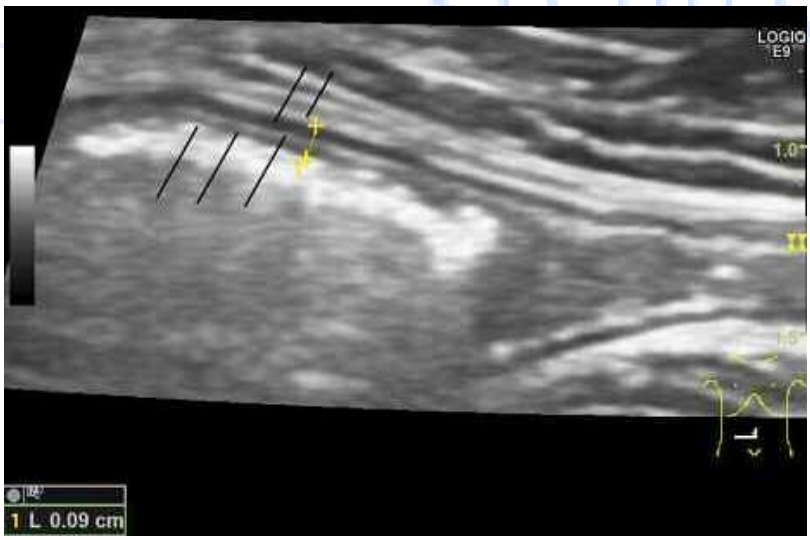
1) intestinal wall (thickness, stratification by layers, length, localization);

2) function (diameter of the lumen, content, change during compression by the sensor, peristalsis);

3) adjacent structures (abscess, fistulas, mesenteric adipose tissue, LN, free fluid) [13].



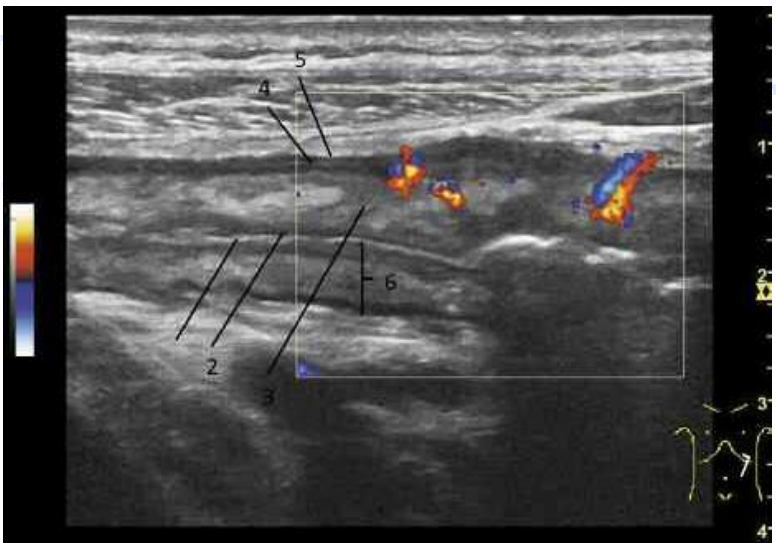
Rice. 2. Echogram of the caecum is normal: a - the symbol (>) indicates the caecum, the arrows indicate the ileum; b – enlarged image of a fragment of the same echogram of the caecum, the wall thickness is 0.9 mm.



Note. 1 - superficial (boundary) echogenic layer; 2 - mucous membrane; 3 - submucosal layer; 4 - muscle layer; 5 - serosa ; the thickness of the intestinal wall is 0.9 mm, indicated by markers (+).

Strengthening stratification (differentiation), i.e. improvement in visualization of the layers of the intestinal wall is observed in acute infections, CD and UC with low activity, rarely with ischemia. The opposite change of this parameter, i.e. loss of stratification, always with wall thickening, occurs in pseudomembranous colitis, acute infections, highly active UC and CD, ischemia, and malignancies. Edema of the mucous membrane of the small intestine is possible with a fairly wide range of diseases: small bowel obstruction, volvulus and compression of the intestine, congenital angioedema, infectious

gastroenteritis, small bowel ischemia, mesenteric venous thrombosis, peritonitis, vasculitis , celiac disease , chemotherapy, tumor infiltration and other pathologies accompanied by involvement mesentery [14]. "White" gut, i.e. its echogenic wall is seen in Whipple's disease , as well as infection caused by Mycobacterium avium in patients with HIV, celiac disease and lymphedema due to various causes. Asymmetric hypoechoic thickening is possible with tumor, diverticulitis , ulcer, and rarely with CD [13]. In UC and CD, for ultrasound assessment of the activity of the inflammatory process in the intestinal wall, the scale of B. Limberg (1999) is used, which takes into account the thickness of the intestinal wall and the severity of Doppler blood flow in the color mapping mode [1, 7]. The higher the value on the Limberg scale (from 2 to 4th degree), the more intense the blood flow and the more pronounced inflammation of the intestinal wall. Japanese authors proposed an ultrasound scale of the state of the intestinal wall to assess the severity of UC (Table 2) [15–17]. Characteristic "X" is provided in cases where it is impossible to visualize a segment of the intestine. In the course of a multicenter study, the authors found that in most cases there is a correlation between US and the endoscopic degree of activity. Thus, the 1st degree, according to ultrasound data, corresponds to endoscopic remission, the 2nd, mild activity, the 3rd, moderate, and the 4th, high UC activity [16, 17]. Our experience shows that such a characteristic as "the presence on the surface of the mucous membrane of small echogenic areas corresponding to ulceration" is ambiguous, difficult to interpret, and overestimation of this symptom can lead to diagnostic errors - false positive diagnosis. At present, the possibility of assessing the dynamics of the activity of the inflammatory process in patients with IBD has been convincingly proven by ultrasound [18, 19]. Among the methods of radiation imaging, ultrasound should be the 1st line of diagnosis in IBD. Although ultrasound signs of changes in the intestine with its structural pathology are found quite often, the echographic symptoms of intestinal diseases are usually not pathognomonic and highly specific.



Rice. 3. Crohn's disease with localization in the descending colon, high activity.

Note. 1 - superficial (boundary) echogenic layer; 2 - mucous membrane; 3 - submucosal layer; 4 - muscle layer; 5 - serosa ; 6 - the total thickness of the intestinal wall is 8 mm; 7 - echogenic thin (1 mm) intestinal lumen.

At the same time, the combination of symptoms suggests sometimes even a fairly rare pathology. So, for example, with celiac disease , you can find:

1) in the jejunum - flattening, sometimes very pronounced, of Kerkring's folds and an increase in the distance between them; in the distal ileum - its " jejunalization ", i.e. the appearance in it of clearly defined circular folds;

2) moderate expansion of the small intestine more than 25 mm, first lean, then ileum;
3) on an empty stomach there is an increased amount of fluid in the lumen of the small intestine and its increased peristalsis, which is why this symptom is called the “washing machine phenomenon”;
4) thickening of the intestinal wall more than 2 mm, occurs in 1/4–1/2 patients and is associated with hypoalbuminaemic edema or vasculitis ;
5) " velvet-like " thickening of the intestinal wall more than 2 mm;
6) an increase in mesenteric lymph nodes with an anteroposterior (transverse) size of more than 5 mm, occurs at least in 1/2 patients, the number of lymph nodes in the mesentery is more than 10, (the length of the lymph nodes can reach up to 17 mm, the shape of the lymph node is oblong and echogenicity is low; small lymph nodes may be rounded; if the LN is rounded and larger than 17 mm, we can assume the presence of T-cell lymphoma associated with celiac disease);
7) slight ascites, a sign is usually determined in severe malabsorption with hypoalbuminemia ; effusion in the pericardial cavity is also possible;
8) an increase in the volume of the gallbladder (more than 25 ml), often with sludge ;
9) liver steatosis is possible , for which there are no usual causes, i.e. overweight, alcohol abuse or exposure to other hepatotoxic substances;
10) small spleen;
11) expansion of the superior mesenteric artery (up to 8–11 mm) and portal vein (up to 13–17 mm) [8, 10].

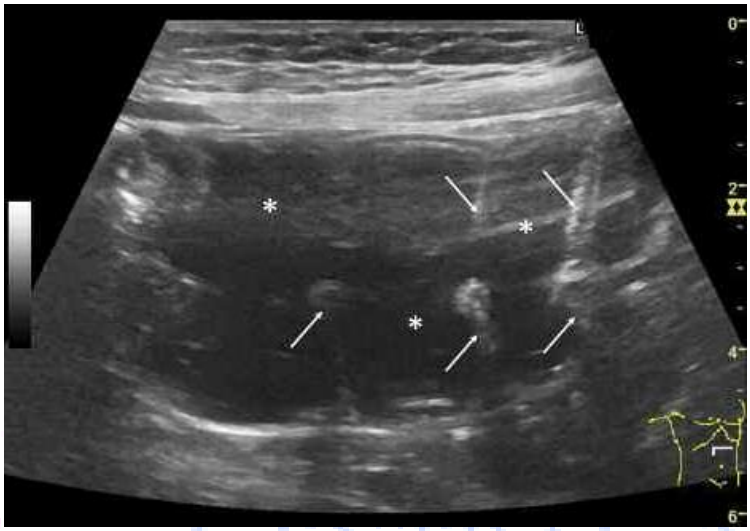
The first 7 of the above signs are possible with HIV enteropathy and autoimmune enteropathy .

Enteroclisis

the enteroclisis technique has been widely used, primarily abroad, with CT and MRI . The technique consists in the introduction through a 1.5-meter Teflon nasojejunal probe with a diameter of 3.1 / 2.1 mm of fluid, which allows you to contrast the small intestine. The localization of the probe is controlled by the image on the screen of the fluoroscope . In the classical version, the CT enteroclysis technique is carried out as follows. 1500 ml of the PEG standard solution is injected through the probe, first manually with a 60 ml syringe, and then continuously with an infusion pump , first at a rate of 150 ml/h, then at 200 ml/h. According to another version of the method, 2000 ml of a 0.5% aqueous solution of methylcellulose is used . Before the start of the study, the patient is injected with a standard dosage of the antispasmodic N- butylscopolamine , which prevents intestinal spasm , provides uniform stretching of the small intestine and reduces the patient's possible discomfort. After the start of the infusion of the solution into the intestine, CT is performed, and contrast is injected (Ultravist 370; Schering AG, Berlin , Germany) and scanning is carried out within 70 seconds after the injection of contrast. On average, the CT enteroclysis technique requires about 15–25 minutes, the radiation exposure is 8 mSV . A similar examination time is needed for MRI enteroclisis . This technique assesses the thickness of the mucosa and intestinal wall, transmural ulcers in CD, enlarged regional lymph nodes, strictures, and prestenotic dilatations [20]. The inconvenience of enteroclysis lies in the placement of the probe and technical problems during the infusion of the PEG solution. The enteroclisis technique was adopted from CT and MRI for the US method in separate studies, and the location of the probe was controlled by the echographic image of the intestine, which made it possible to avoid radiation exposure. In clinical practice, this technique is almost never used in our country and abroad [19].

small bowel contrast

A more progressive and most popular variant of small intestine ultrasound in foreign studies is small bowel contrast ultrasonography (small intestine contrast ultrasonography - SICUS), which was proposed by Italian researchers almost 20 years ago [21]. The patient should not eat before the study during the night or 6 hours. According to the SICUS method , the patient on an empty stomach self-administers 250-500 ml of PEG solution, usually used in preparation for colonoscopy . Some authors suggest taking 750 ml of PEG solution orally, others - 800, 1000 and even 2000 ml.



Rice. 4. Echogram of the transverse colon is normal after PEG ingestion.

Note. Arrows indicate gaustra ; * – contrasted intestinal lumen.

The study according to the SICUS method is carried out with a 15-minute interval until the solution is evacuated from the small intestine. The duration of the study is about 30 minutes. According to the literature, due to its simplicity, this technique is used in the vast majority of small intestine ultrasound examinations abroad and can significantly improve the visualization of the intestinal wall [22].

Application

SICUS allows to obtain a better image of the intestinal wall, as well as to a certain extent to standardize the study, which is necessary when assessing the diameter of the intestine, its peristalsis and tone [4]. A meta-analysis published back in 2008 showed that the accuracy of diagnosing IBD using ultrasound, CT and MRI of the intestine does not differ significantly [3]. The criterion for ultrasound assessment of the pathology included only thickening of the intestinal wall by more than 4 mm. Over the past decade, more effective methods of ultrasound, CT and MRI of the intestine have been developed, however, the capabilities of these methods are considered close [4]. A 2016 meta-analysis found that SICUS in CD is an accurate and informative method for assessing the location, extent, thickness of the inflamed bowel wall and complications of the disease, such as stricture, prestenotic dilatation, abscess, and fistula [23].

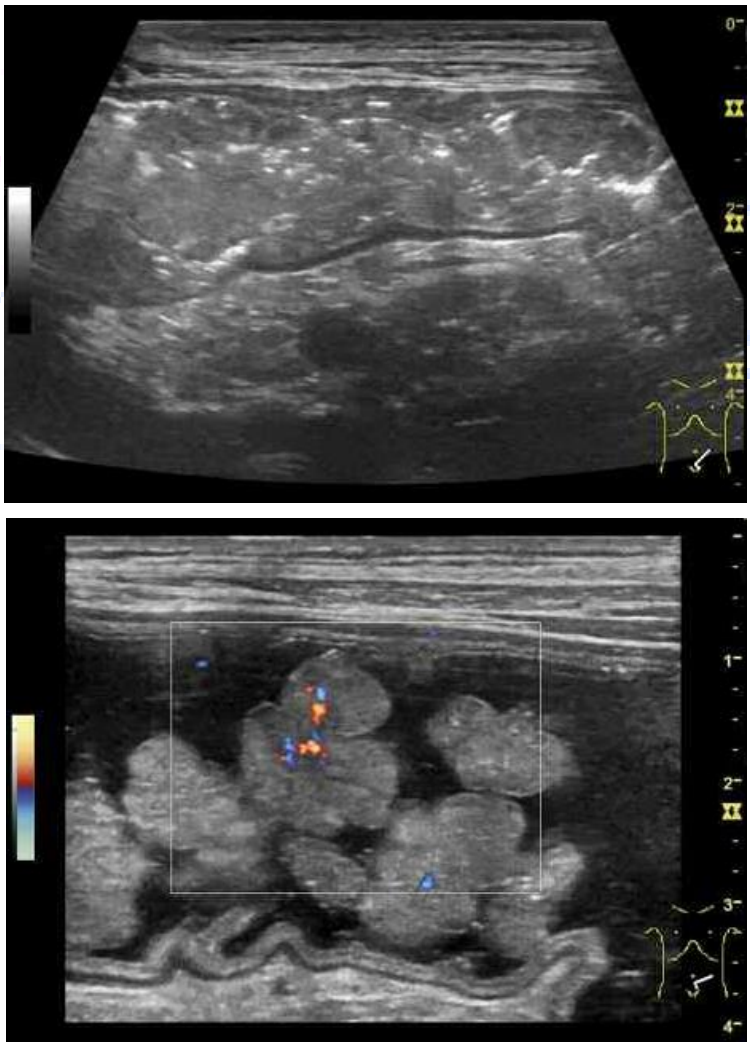
Ultrasound irrigoscopy

With ultrasound irrigoscopy, fluid is injected through the rectum and then a transabdominal examination is performed. This technique has been known since the 1980s [12, 24]. In the classical version, after taking a laxative, 1500 ml of water is installed in the rectum with an enema, and a myospasmolytic , for example, 20 mg of scopolamine -N- butyl bromide , is administered intravenously beforehand . Liquid for injection per rectum with ultrasound irrigoscopy , various methods were offered - water, saline sodium chloride solution, a special diagnostic medium, etc. The technique was used in a number of cases, allowed to improve the visualization of the intestinal wall,

but it has not been widely used in practice and in scientific research [10]. This is probably due to significant technical difficulties for the patient and the need for additional medical staff.

small intestine and large intestine

contrasting with oral pEG Back in 1989, the Japanese specialist Noboru Hiroka et al . proposed to perform an ultrasound of the colon after ingestion of 900 ml of deaerated water with sorbitol. Previously, bowel movements were performed after taking laxatives. The authors demonstrated an increase in the diagnostic capabilities of ultrasound of the pathology of the colon [25]. A more promising approach seems to be the study of the intestine after the application of per os PEG solution in accordance with the rules for preparing for colonoscopy . In this case, it is possible to visualize both the small and large intestines, and not only the anterior one, as is usual in the study on an empty stomach, but also the posterior intestinal wall [2, 10]. In addition to the high quality of the image of the colon obtained by oral preparation, in our experience, patients are fairly well committed to this diagnostic option. The proposed technique actually represents an extended version of the small intestine contrasting described above with an additional examination of the large intestine, i.e. corresponds not to SICUS , but to SLICUS (small and large intestine contrast ultrasonography).



Rice. 5. Diffuse polyposis : a - examination of the sigmoid colon without preparation, identification of polyps is impossible; b – oral contrasting of the intestine with a PEG solution was performed; in the same patient, many polyps with blood flow are visualized in the sigmoid colon.

The technique is based on a standard two - stage colonoscopy preparation scheme . On the evening before the study, the patient should ingest the first half of the dose of PEG, dissolved in 1-2 liters of liquid, in accordance with the instructions for use of the drug. We used the drug Moviprep (Takeda , Japan), or macrogol 3350 (PEG). Contraindications to the use of the drug correspond to those indicated in the instructions and include, in particular, toxic megacolon and intestinal obstruction. Then the patient should appear in the morning on an empty stomach for an intestinal ultrasound, after which he takes the second half of the dose, then the study is repeated after 30–120 minutes, depending on the area of interest. Thus, the stages of ultrasound according to the technique of small and large intestine contrasting with oral PEG (SLICUS) are as follows:

I. Examination of the small intestine and colon with the assessment of the above parameters without preparation on an empty stomach or after a meal before taking PEG. Usually this stage is an integral part of the echography of the abdominal organs. The anatomy and the above-described parameters of the intestine should be assessed.

II. Evening (approximately at 19-20 h) taking a half dose of PEG. In this case, in the case of Moviprep, the first half of the dose is dissolved in 1 liter of water and an additional intake of 0.5 liters of an acceptable (permitted) liquid (water, tea, transparent non-carbonated drinks, non-acidic juice without pulp, for example birch, apple, light grape) . There is no need to use cleansing enemas. For this and all subsequent steps, the patient must follow the instructions: when urged to defecate, one should be ready to empty the intestines without hindrance.

III. In the morning on an empty stomach, the patient is on an ultrasound of the intestine, which must be voluntarily emptied. It should be borne in mind that for the diagnosis of IBD and diffuse changes in the intestine or segments of the intestine, this stage of the study is the main one, therefore, a thorough assessment of the intestinal wall is required. The thickness of the intestinal wall and its characteristics (blood flow, stratification) should be assessed at this stage or at the very beginning of the study (I), if then the visualization was good.

IV. Immediately after completing stage III, the subject should take a second dose of PEG.

V. 30 minutes after taking the second dose of PEG, intestinal ultrasound is repeated. The focus is on the small intestine. As a rule, at the beginning of the study, the jejunum is predominantly filled, towards the end of the study, the ileum is filled to a greater extent.

VI. 60-180 minutes after the second dose of PEG, intestinal ultrasound is performed again. The focus of ultrasound is on the colon. The study is carried out with the patient lying on his back, as well as on his left side. In the latter case, the ultrasound picture of the transverse, descending and sigmoid colon improves significantly. There are usually no problems with visualization of the ascending colon. The use of contrasting with PEG solution can significantly improve the examination of the intestinal wall (Fig. 4).

Already after the initial stage of preparation (intestinal cleansing), visualization of the lymph nodes located behind the intestine often becomes available, and after filling it with a PEG solution, such an examination becomes much easier. After contrasting with a PEG solution of the colon, local changes in the intestinal wall, primarily exophytic tumor formations, which were previously masked by intestinal contents (Fig. 5), as well as stenotic areas are determined quite convincingly. At the same time, due to stretching of the intestine, diffuse inflammatory changes in its wall are visualized worse, as its thickness decreases.

At the stage of primary examination without filling the intestine with a PEG solution in the process of differential diagnosis of polyps and local parietal location of intestinal contents, which is often a significant problem, Doppler mapping should be used, better directed energy, which reveals

reproducible blood flow in the tumor. An important feature of the technique with PEG is its relatively physiological nature, which makes it possible to study the functional characteristics and the effect of pharmacological agents on intestinal motility. With a limited number of examinations, an ultrasound of the intestine at stage III is mandatory (in the morning before the second dose of PEG) and, at a minimum, another examination is required after 60-120 minutes. If the small intestine is of particular interest, repeat ultrasound should be performed 30 to 60 minutes after the second dose of PEG. In the case when a detailed examination of the colon is necessary, it is advisable to repeat ultrasound 60-120 minutes after taking the second dose of PEG. In addition to the standard contraindications to the use of PEG, the limitations of the SLICUS technique are patient obesity and individual characteristics of gastrointestinal evacuation. To level the latter limitation, it is necessary to assess the evacuation of fluid from the stomach, the presence of contrast in the small intestine, and, in some cases, perform an ultrasound of the colon 3–4 hours after taking the second dose of PEG.

Conclusion

Thus, ultrasound is currently a popular method for diagnosing and evaluating the effectiveness of treatment of intestinal diseases. The use of oral PEG contrast enhances the possibilities of ultrasound detection of changes in the intestinal wall.

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