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Contrast ultrasonography of the digestive tract lumen. Review of the literature and personal experience

R. Badea[1], Lidia Ciobanu[2], Adriana Gomotirceanu[3], Claudia Hagiu[2], Mihai Socaciu[1]

[1]Dep Ultrasound, 3rd Medical Clinic, „Iuliu Haţieganu" Cluj Napoca,
[2]3rd Medical Clinic, UMF „Iuliu Haţieganu" Cluj Napoca,
[3]Medical Center TOPMED, Târgu Mureş

Abstract

Routine exploration of the digestive tract is performed under „fasting" condition, without further training. The investigation is limited due to hidroaeric and alimentary content and deep location of some digestive parts (gastric fornix, colon flexures). Oral administration contrast agents cause a distension of the digestive lumen which allows a satisfactory viewing of the „hidden" regions and endoluminal detection of small formations. A combination of conventional and contrast ultrasound brings additional information which increase the overall performance of the ultrasound method.

Keywords: Digestive tract contrast, SonoVue, ultrasound

Rezumat

Explorarea de rutină a tubului digestiv se efectuează în condiţii „ a jeun" fără o altă pregătire. Investigaţia este limitată din cauza conţinutului hidroaeric şi alimentar sau dispoziţiei profunde a unor componente digestive (fornix gastric, flexuri colonice). Administrarea de contrast lichidian pe cale orală realizează o distensie a lumenului digestiv ceea ce permite vizualizarea satfisfăcătoare a regiunilor „ascunse" şi detectarea formaţiunilor endoluminale de dimensiuni mici. Combinarea dintre ecografia convenţională şi cea cu contrast luminal permite obţinerea de informaţii suplimentare ceea ce duce la creşterea performanţelor de ansamblu a metodei ecografice.

Cuvinte cheie: tub digestiv, contrast, SonoVue, ultrasonografie

The importance of the problem. Examination of the digestive tract is one of the „challenging" applications for ultrasound. The obtained information from routine exploration is not always very eloquent in order to make an accurate diagnosis. Even if the digestive tract is accessible for routine investigation, most of its segments being located superficially under the anterior abdominal wall, there are limitations that can lead to errors with false positive or negative diagnosis. Some of the errors are due to: a) inability of viewing certain digestive segments ex. gastric fornix, gastric posterior wall, colon (particularly the flexures), anorectal region; b) abundance of heterogeneous elements in the digestive lumen such as gas and food debris which mask the structures of interest, mainly tumor and/or inflammatory; c) variability of ultrasound appearance from one moment to another of the investigation (the digestive tract being permanently dynamic and peristaltic); d) tortuous path and pathological features of different parts of the digestive tract, each with characteristic syndromes; e) lack of standardized procedures for examination and operator-dependent nature of digestive exploration.

Despite these limitations, ultrasonography (US) remains the first choice imaging method in patients with abdominal pain, abnormal transit, weight loss, etc [1]. The method has the safety advantage, non irradiant character and the ability to provide „real time" information, with excellent visualization of the intra-abdominal organs, which allow the identification and characterization of inflammatory processes and tumors [2]. Information related to the digestive tract is usually supplemented with those relating to the status of other digestive organs of-

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Address for correspondence: Radu Badea
Dep Ultrasound, 3rd Medical Clinic,
19-21,Croitorilor str.
400 162, Cluj Napoca, Romania,
E mail: rbadea@umfcluj.ro

ten involved in digestive pathology such as peritoneum (peritonitic processes, ascites), lymph nodes (inflammation, tumor), liver (abscess, metastasis) [3]. In addition, there are procedures to optimize the method, leading to an increased performance of transabdominal ultrasound evaluation of the digestive tract [4]. Among these are the administration of contrast agents, orally for the investigation of the stomach or small intestine or anal for exploring the colon and rectum. This procedure is associated with other ultrasound techniques of great potential; contrast-enhanced ultrasound is used with good results for characterizing microcirculation in various disease [5,6].

Oral or anal contrast enhanced ultrasound (CEUS), like the conventional procedure (US), is always made under „fasting" 12 hours preceding the investigation. Regardless of the contrast agent quality, the digestive wall has the same aspect: a) thickness of 4 to 5 mm; b) multilaminar structure, consisting from lumen outwards of the following layers: hyperechogenic (liquid/mucosa interface); hypoechogenic (mucosa); hyperechogenic (mucosa/muscularis mucosae and submucosa interface); hypoechogenic (muscularis propria); hyperechogenic (serosa) [7]. The digestive lumen is disposed in the shaft, having a variable size depending on the time of investigation (contraction or relaxation) and the segment examined.. The digestive lumen is disposed in the axis, having a variable size depending on the time of investigation (contraction or relaxation) and the segment examined. Spatial orientation, the path and the ultrasound examination window are dependent on the viewed digestive segment.

Contrast agents used in exploring the lumen of the digestive tract. Contrast agents used to examine the digestive fluids are nontoxic substances and they have similar organoleptic characteristics of food. For the ultrasonographic exploration of the digestive tract are used:

a. *water* – is the most accessible contras agent, used in variable amounts depending on patient tolerance, averaging 150 to 300 cc. It can be used both for exploration of the stomach and colon. It has the disadvantage of a inhomogeneous air content which disturbs the ultrasound image when ingested or enema administrated. However, after a few minutes after instillation, air bubbles dissolve in water leading to achieving a good contrast between the lumen and digestive tract walls.
b. *contrast agents dedicated* to examination. This category includes substances based on cellulose and simethicone. They are prepared iso-osmolar to avoid internal dehydration, non-absorbable and unfermented, tolerable by the patient. Due to much lower gaseous content than water, almost insignificant, these allow a good examination of the digestive wall. Mucosal surface is well emphasized by creating a hypoechogenic homogenous environment at the lumen level. It is used to investigate the stomach [8] or the small intestine [9,10]. The substance frequently used for intestinal study is Macrogol 4000 (trade name Fortrans). A rapidly preparation is made by a balanced mixture of polyethylene glycol (PEG), sodium and potassium salts, dissolved in 1000 ml of water (standardized preparation Klean - PrepTM, Norgine, Italy). These substances prepare the digestive tract for endoscopic examination of the colon.
c. *contrast agents combined with gas-filled micro bubbles*. This category includes water, the most accessible contrast environment, which can be combined manually with 1 to 2 drops of contrast agent used in liver applications (SonoVue). The mixing result is non-toxic, easily swallowed or administered as an enema. An intraluminal homogeneous environment but intensely echogenic is obtained which allows a very good analysis of the digestive wall. It has the disadvantage of dependence of SonoVue. The method allows the examination using broadband transducers (harmonious exploration), both in gray scale and with intravenous contrast examination software which leads to a very good contrast of the lumen relative to the digestive wall. The applications relate to the study of the esophagus and stomach and also descending colon.

Regarding the contrast agents where there is a good contrast in the digestive tract of physiological or pathological reasons, practical solutions should not be omitted. This category includes state of hydration or food excess that can sometimes lead to a high quality ultrasound image, especially in the stomach or duodenum. At the bowel level, fluid in excess is pathological, being present both in benign conditions (common diarrhea syndrome) and in severe inflammation or tumor pathology. Thus, the adult chronic abdominal pain syndrome associated with fluid excess in the intestine may draw attention to a gluten enteropathy [11].

The objectives of the examination of the digestive tract with CEUS are: a) physiological distension of the digestive lumen in order to highlight the path of the examined organ and peristaltic peculiarities; b) achieve optimal interface between the digestive mucosa and lumen to allow a detailed analysis of the digestive wall structure, with accurate assessment of stratification, quality and thickness of each component layer and thickness of

the whole wall; c) detecting mucosa relief accidents, susceptible to be tumors (benign or malignant) and in-depth assessment degree of penetration to the preoperative tumor staging process; d) production of digestive acoustic windows filled with fluid elements in order to examine the structures and organs located posterior, especially in the retroperitoneal space hardly investigated in normal (ex. pancreas tail visualized with gastric/colon hydrosonography) [12]; e) to create optimal conditions for three-dimensional reconstruction of the digestive lumen.

Equipment and techniques for exploration. Transabdominal exploration of the digestive tract using broadband transducer of 2.5-3.5-5 MHz. For the digestive structures located superficially (appendix, last ileal loop, sigmoid colon) and when a detailed analysis of anatomical structures is wanted, the soft parts transducer with frequency of 7.5 to 12 MHz is used. Most common procedure used in gray scale is the technique of „tissue harmonic imaging" (THI) and „phase inversion harmonic imaging" (PIHI). The two procedures are characteristic to broadband transducers. They emit ultrasound in the basic range of 2.5-3.5-5 MHz and receives echoes both basic and their harmonics, in nominal values, they are integral multiple or ½ from them. These types of transducers are needed due to the diverse range of echoes generated by the tissues and leads to high quality images with high resolution, regardless of the depth in the region of interest. Also they permit the maintaining of the dynamic range which provides a good contrast to the examined structures. Moreover, the two modes - THI and PIHI - co visualize the harmonic echoes returned by gas microbubbles which explains their use as oral or rectal contrast environment [13,14]. In all these cases, the ultrasound image will be in gray scale; and examination procedure of investigation will be in real time. When there is interest in blood vessels analysis the Doppler technique, the CFM mode (for selecting the region of interest), pulse (for assay of blood flow) and power (to identify the slow flow) as well as contrast agents with intravascular administration it will be used. Doppler technique is used mainly for the study of large vessels and vessels pedicles entry in organs while CEUS technique is used primarily for analysis of microcirculation of the digestive wall [15]. To study the digestive lumen, patients will be given oral contrast agent (for the study of the abdominal esophagus, stomach, duodenum and small intestine) or by ano-rectal, enema form (for the study of the rectum and colon). Examination of the rectum and anal canal can be done after instillation of contrast agent (in quantities of 200 to 300 cc) and the penetration using endocavity transducer with frequency of 7 to 12 MHz. In women, the rectum and anal canal can be explored at a very good quality, after filling the rectal ampulla with contrast agent and using the endovaginal approach.

Clinical applications

Abdominal esophagus. The patient is placed in dorsal decubitus. The transducer is positioned in the epigastric region, just under the xiphoid appendix, oriented obliquely toward the left hypocondrium.

Normal appearance of the abdominal esophagus is a tubular structure with a length of 2 to 3 cm hypoechogenic walls, with a thickness of 4 to 5 mm. The esophageal lumen is short and ordered in the organ axis. After contrast administration the lumen „opens" for a short period followed by progression to the fornix. The transducer used is convex, with 3.5-5 MHz frequency. Esophageal wall structure can not be examined using transabdominal ultrasound. Transabdominal ultrasound exploration cannot easily discriminate between esophageal pathology of the region and eso-cardio-tuberosity. However, careful investigation may identify the region, in the case of neoplasm, by a pronounced thickening and alteration of the wall structure and the esophageal lumen having an asymmetrical trajectory irregular, winding. Contrast administration reveals the lumen and suprastenotic dilatation of the esophagus. In the case of esophageal achalasia the wall is thickened with preserved structure, hyperechogenic. The lumen is narrowed and appears in the center of esophagus. One can find pronounced dilatation of the esophagus with „hourglass" aspect above the stenotic segment.

Stomach. The patient is placed in dorsal decubitus or can be rotated depending on the region of interest. Thus, in the Trendelemburg position, the fornix and the stomach body can be seen; in the left lateral decubitus position the stomach can be examined and in the right lateral decubitus position the antrum and duodenal region can be seen. The examination window is represented by the epigastric region (for the stomach and the antropyloric region) and the intercostal spaces IX - XI on the left, through the spleen, (to view the fornix and eso-cardial angle). A convex transducer with a 3.5-5 MHz frequency should be used. Working equipment will be based on the simple harmonic software or harmonic combined with pulse inversion. The latter should be used with or without oral contrast administration, having the capacity to provide a higher contrast image, useful for viewing interfaces without a significant reduction in the dynamic range. Stomach exploration is completed after administrating the patient, under „fasting", a quantity of 200 - 300 ml of contrast agent. Alongside this procedure an adminis-

tration of 20 mg of Buscopan, intravenous (Boehringer, Germany) for relaxation of the stomach can be administered which prevents precipitated discharges. Oral CEUS stomach exploration objectives are mainly: the detection and identification of peristaltic abnormalities, tumors, combined or not with gastroesophageal reflux. The performance of the procedure is reduced when weight status is excessive and when there is somatic features including chest wall deformities, abdominal retractile scars following surgery, etc.

Normal appearance of the stomach is tubulo-hollow organ, with stratified walls. At 20 to 30 seconds after oral contrast administration, there is a distension of the lumen to values of approx. 5 to 6 cm at the body level and 3 to 4 cm at the antrum level. Wall thickness is between 4 and 5 mm and it has a layered structure.

Gastric pathology, as is visible on ultrasound examination can be systematized in disease evolving with diffuse thickening of the walls and disorders characterized by circumscribed, localized thickening.

Gastropathies evolving with diffuse hypertrophy of the wall. A group of stomach problems detectable by routine transabdominal ultrasound which is expressed by pronounced and diffuse thickening of stomach wall, often exceeding 10 mm may be formed. This category includes: hyperplastic hypersecretory gastropathy (Menetrier), gastric lymphoma, infiltrating gastric carcinoma (scirrhous) acute hypertrophic gastropathy and parasitosis (such as the infestation with Anisakis worms through the ingestion of unprepared meat from sea food). When examining the native aspect it is quite uncharacteristic, presenting only stomach wall thickening and lumen collapsing. This procedure can not make a valid discrimination between benign and malignant pathology. After administration of contrast agents the distension of the stomach is obtained which allows detailed analysis of functional anatomical peculiarities. The criteria used to formulate a diagnosis are: stomach distension after administration of contrast agents (global or segmental), wall thickness (normal - approx. 4 to 5 mm / pathological - over 4 - 5 mm), and thickening distribution considered pathological (diffuse/localized), the wall aspect (stratification/altered stratification), characterization of the pathological layer of stomach wall (thickness and echogenicity), stomach compressibility on palpation with the transducer, peristaltic movements (present/exacerbated/reduced/absent during exploration). Based on these criteria, it can discriminate between the disorders listed offering a very good performance reaching up to 100% sensitivity and specificity of 100% for Menetrier's disease; 67% respectively 92% for acute gastritis with parasitosis; 97% respectively 72% for other causes of acute gastritis, 100% and 100% for infiltrating lymphoma and carcinoma [16].

Gastropathies evolving with circumscribed thickening of the wall are the primary malignant tumors (carcinoma, lymphoma, sarcoma), metastasis or benign tumors. Malignant gastric tumors have a nonspecific appearance, regardless of histological substrate. Parietal structure can be preserved, with multilayered appearance or it seems to „delete" the division between layers of the stomach. It is important to note that the tumors infiltrating processes can be difficult to prove with ultrasound examination! Indirect signs are the disappearance of stomach distension after administration of water and increased echogenicity of serosa which may suggest the existence of peritoneal dissemination. Peritoneal carcinomatosis can be supported by identification of peritoneal fluid (ascites) and signs of metastasis (liver tumors, or, in women, ovarian Krukemberg syndrome). Proliferating tumors appear as internal anfractuosities of the gastric wall, easily shown after the administration of contrast agents. Mucosal surface is irregular, with areas of increased echogenicity usually associated with erosion or ulcerations and tumor structure is mixed, with varying vascularisation. The range of implantation of the tumor and invasion of all layers even exceeded serosa and invaded neighboring organs could be evidenced. Stenosing tumors are identified such as an excessive increase in the thickening of the stomach wall, larger than 10 mm, associated with the presence of a narrowed lumen. Frequently coexisting with a pronounced dilatation of the stomach upstream. Oral CEUS shows more clearly the stenosis path and tumor area. In the tumor staging process, the method cannot compete with echoendoscopy. However, in well defined cases, given the very wide addressability of the transabdominal examination, considered as non-invasive and being well tolerated by patients, identification and staging of the gastric tumors can be done with encouraging performances. By gastric hydrosonography approx. 69% to 95% of all submucosa tumors detected with echoendoscopy were identified, if their size was more than 22 to 30 mm [17,18]. In the TNM staging process, the gastric hydrosonographic technique has a 41% sensitivity for detecting tumor invasion into the wall and 61% in identifying lymph nodes [19].

Benign gastric tumors can be detected by ultrasound starting from 5 mm in diameter. It appears as a bump of mucosa surface, with no echogenic elements, relatively homogeneous, well-defined, encapsulated, and without serosa infiltration. It can be pediculate or sessile.

Gastropathies evolving mucosal discontinuities and destruction of the wall. In this category the significant erosions of the mucosa from severe gastritis and gastric ulcer are included. The appearance of ultrasound is

„caught" echoes at the eroded or ulcerated surface level (due to the air microbubbles fixed at the level of pathological areas). Gastric parietal discontinuities may correspond to gastric fistulae with retroperitoneal cavities, such as pancreatic pseudocysts. These are emphasized by the comportment of the contrast fluid during the palpation with the transducer: the liquid can be moved from the stomach into the retrogastric cavity, a phenomenon that can be revealed with CFM.

Based on the property of gas microbubbles to increase the echogenity of the „transport" liquid, we used an „improved" technique of oral CEUS by adding 1-2 drops of SonoVue in 200 ml water. We examined five patients with gastric neoplasm first by oral CEUS using the „harmonic tissues" technique then using enhanced oral CEUS gas microbubbles using „harmonic tissue" and „phase inversion". The use of „harmonic tissue" in the presence of gaseous microbubbles allowed a better description of the location, the extension and gastric tumor invasion process in the structures of the digestive wall and adjacent structures than with simple administration of oral contrast agent. This can be explained by the increasing lumen echogenicity, more homogeneous in the presence of microbubbles than in classical hydrosonographic examination. Although the number of patients does not allow us a statistical quantification, we observed that using the „harmonic tissue" in the presence gas microbubbles into the gastric lumen, the posterior wall of the gastric body is better explored (fig 1). In a patient with gastric lymphoma operated for compressive lymphadenopathy in the main biliary duct this technique allowed the evidence of a functional biliodigestive anastomosis. However details on the tumor transformed surface (erosions, ulcers) were better highlighted by using the technique of „phase inversion". This technique uses a low mechanical index, suppresses the tissue harmonic data, so that echoes from gas microbubbles become more evident, providing a good contrast of the lumen relative to the digestive wall. Thus, it provides the evidence of the exulcerated nature of gastric tumors.

Duodenum. Ultrasound exploration with contrast of duodenum is made in addition to stomach investigation. The patient is in dorsal or right lateral decubitus (favoring precipitated leakage of the contrast material and distension at this level of the duoudenal lumen creating the possibility for a proper analysis of the mucosa surface). Window approach is epigastric and right hypochondrium. Contrast agent can be water or water combined with SonoVue.

Normal aspect is a tubular structure with a lumen of 2 to 3 cm in the phase of distension, with large contractions that go up to the complete disappearance of the lumen. Mucosa surface is smooth.

Pathology. Contrast examination is necessary to highlight the lumen stenosis (inflammatory or tumor), circumferential or eccentric parietal thickening, relief accidents with lack of substance (in ulcer disease) or excrescences (mainly ampullary tumors). After the administration of contrast agents an optimization of Vater ampulla can be achieved and a better discrimination of pathological substrate at this level - tumor or inflammatory (after a recent stone passage or even to identify the stone enclavation in papilla).

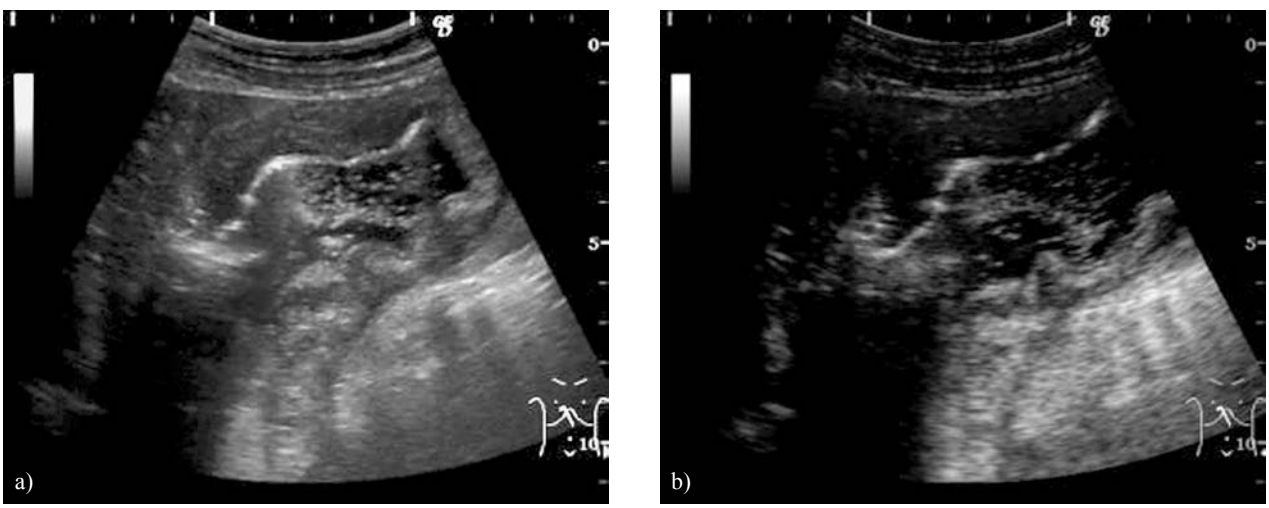


Fig 1. Oral contrast agent US optimized with SonoVue in a patient with gastric lymphoma of the anterior wall, above the stomach body a) „harmonic tissue" technique – parietal thickening with loss of stratification. Posterior wall with normal stratification; b) „phase inversion" technique – better contrast between lumen and mucosa, identifying ulcerations on anterior thickened wall and normal appearance of posterior wall.



Fig 2. Oral contrast agent US optimized with SonoVue „harmonic tissue" technique. Duodenal ulcer – gas microbubbles accumulation into eroded mucosa.

We had one case in which hydrosonography with 1-2 drops of SonoVue and „harmonic tissues" technique highlighted at the duodenal knee level a thickened, hypoechogenic wall (fig 2). Subsequently, the contrast software revealed an accumulation of echoes on the surface, allowing the identification of a duodenal ulcer

Intestine. The patient is in a dorsal decubitus position. The window approach is the left hypochondrium (for the first jejunal loop), periumbilical and hypogastrium (to see jejuni and ileum) and right iliac fossa (terminal ileum). Commonly used is the convex transducer with a frequency of 3.5 to 5 MHz. Additional information can be obtained by using PIHI mode (generally used for the examination of intravascular contrast). This allows the use of high frequencies for structures located superficially, increasing contrast and eliminating partially the artifacts echoes returned by intraluminale gas and food [13,15]. For the last ileal loop the transducer of soft parts (7-12 MHz) can be used.

Ultrasound exploration with luminal contrast of the small intestine is carried out continuously or sequentially, starting at about 15 to 20 minutes after oral administration of contrast agent and continuing every 5 to 10 minutes until the contrast become visible in the terminal ileum. The total duration of the investigation is 20 to 30 minutes, sometimes longer if there are stenosis or fistulas. The amount of contrast agent administered is 500 to 800 cc, usually well tolerated by patients.

Normal appearance of the small intestine is a tubular, thin-walled, with a layered look, with lumen ranging from unapparent up to 1-2 cm in the phase of relaxation. After the administration of the contrast agent the intestinal lumen is relaxed and the peristaltic waves become more evident in the sequence and amplitude. Intestine contractions are more ample in the jejunum and less obvious in the ileum. Intestinal wall is layered, with an overarching thickness of 3 to 4 mm. Mucosa surface is irregular and the contrast allows the visualization of circular folds [11].

Pathology. The criteria used to formulate a diagnosis (normal/pathological) of the small intestine are: intestinal wall echogenity and morphology, lumen appearance (dilated or stenosis), distribution of pathological changes (localized, diffuse or multisegmental disposal), elasticity and peristaltic movements of the intestinal wall (normal, absent, exacerbated), endoluminal of tumor type changes, fluid between intestinal loops or inside peritoneal cavity (ascites), presence of peri-intestinal abscesses and fistulas, mesenteric and epiploic structures appearance (conglomerates, retraction of intestinal loops), presence of mesenteric lymph nodes.

The main diseases identified through this procedure are inflammatory diseases, especially Crohn's disease, and primary (rare) or metastatic tumors. In Crohn's disease the use of transabdominal contrast ultrasound permits the identification of the disease with a sensitivity of 93.7% to 100% depending on the segment (the worst performance is expected in exploring the proximal ileum) [10]. Characteristic changes are the significant thickening of the wall, with transmural aspect, the narrow lumen, the significantly reduced of compliance (elasticity) and peristaltic movements, thickening and hyperechocenicity of adjacent mesenteric fat, and perintestinale fistulas or abscesses formation. Accuracy of diagnosis of intestinal Crohn's disease using lumen contrast ultrasound is 96.1%. There is a high single stenosis detectability rate (sensitivity 72%, specificity 93%) and a degree of overlap with the diagnosis made by enema up to 0,95 [10]. Performances are increased also in the complex complications that need surgical treatment. Thus, in the detection of multiple stenosis, conventional ultrasonography has a sensitivity of 55% and in the identification of fistulas, 80%. After administration of oral contrast agent, the diagnostic performance increases to 78% respectively 86% for the two types of complications [10]. In gluten enteropathy US detects dilatation of intestinal loops, wall thickening, reduced number of circular folds and increased peristaltic contractions especially at the jejunum level [20]. Peristaltic movements are globally exacerbated involving the whole intestine. Frequently inflammatory mesenteric lymphadenopathy is also present.

Colon. Patient is in dorsal decubitus position and a 3.5 to 5 MHz transducer is used. When the patient is normo/underweight, the transducers for soft parts, with 7 -10 MHz frequency, optimal for exploration of the sigmoid

colon, the ascending colon and the last ileal loop could be used. Exploration of the colon consists of continuous monitoring of progression of contrast agent administered as an ano-rectal enema.

A quantity of 1000 -1500 ml contrast agent basal or SonoVue optimized is required. The enema may also include the intravenous administration of 20 mg Buscopan designed to achieve a smooth muscle relaxation. The procedure has maximum efficiency if the bowel has no food debris (a vigorous purgation or an examination prior colonoscopy is advisable). The window approach is the hypogastrium (to view the sigmoid colon, and the first part of rectal ampulla), flanks and both left and right hypocondrium (descendant, ascendant colon and the flexures) and periumbilical (above or under the umbilicus) to explore the transverse colon.

Normal aspect of the colon is a tubular structure with the lumen of 4 to 5 cm, layered walls, with an average thickness of 4 to 5 mm. The haustra are visible at the colon level without any other excrescences on the internal surface of the mucosa. Examination with water contrast agent is generally well tolerated and allows the view of the colon in its entirety.

Pathology. The criteria used to formulate a diagnosis of normal or pathologic colon are represented by the walls distensibility, the normal diameter of the lumen and its central position, 4 to 5 mm thickness of the walls and layered aspect, no excrescences on the mucosal surface, presence of the haustra, without adenopathy and pericolonic collections, and no pain during transducer palpation. Through this procedure, the tumors, lumen stenosis and parietal thickening could be identified [21,22]. In *colon cancer* the method is useful to confirm the tumor suspicion, to assess the degree of digestive wall involvement and to grade the lumen stenosis [23]. The tumor appears like a significant thickening of the walls with destruction of layer structure. The site of the tumor is eccentric and the lumen is deviated and stenosis. During transducer palpation and when administrating the contrast agent an induration and increased rigidity of the digestive wall at the tumor level is found. Ano-rectal CEUS has a good accuracy to allow detection of 5 mm size *polyps*. They appear as an echoic outgrowth, well defined, with the narrow implantation on the surface of the colon mucosa [24]. After water contrast agent administration *peritumoral metastatic adenopathies* are easier to be examined. Overall performance of hydrosonography concerning detection and characterization of tumors are dependent on the patient's weight status (it is relatively difficult to examine overweight patients), the readiness of the colon, the examiner's experience and the location of the tumor. It is easier to reach a diagnosis when the tumor is located on the left colon, which is more accessible for examination, than on the right colon or rectum. In intestinal occlusion *emergencies* hydrosonography may be useful in detecting the site and cause of obstruction, especially in the left colon and also for the treatment, in case of tumefaction in children. In case of *diverticulitis* a diverticula is identified as round or oval foci that protruded from the colonic wall, with focal disruption of the normal layer continuity, passing through the seroasa. Frequently, during exploration with contrast, extensive hypoechogenic thickening of colon wall can be seen. This aspect correlates with the existence of the associated colitis. The reduction of lumen distensibility suggests fibrosis due to repeated episodes of recurrence. The method is valuable also for excluding diverticulitis (in basal conditions it may be falsely diagnosed). In inflammatory bowel diseases, hydrosonography is useful for the detection of stenosis areas and pericolic fistula paths (Crohn's disease) and for assessing the extension of active inflammatory process (hemorrhagic rectocolitis) [25]. The administration of contrast agent into the colonic lumen shows better the parietal structure affected (at the mucosa level in hemorrhagic rectocolitis and with transfixion aspect in Crohn's disease). Assessing the activity of Crohn's disease can be achieved by using the Doppler method or by intravenous CEUS [26,27].

In three patients with active colonic Crohn's disease, ano-rectal CEUS examination improved by the addition of gas microbubbles, helped us to define the way of evolution of the disease according to Vienna classification (2 patients – inflammatory; 1 patient stenosis; no one with fistula type). Tissue harmonic imaging and microbubbles creates high accurately images, permitting the identification of the regions of the affected colon, and the nature of the stenosing disease process (fig 3) by assessing the peristaltic movements and the distensibility on the affected region. Examination by phase inversion permits the examination of pseudopolyps by creating a good contrast to the interface between the lumen and mucosa. Application of this method is very useful in monitoring the effectiveness of therapy; the method is easily acceptable to the colonoscopy, because of non-invasiveness.

In five patients with ulcerative colitis ano-rectal CEUS exploration with SonoVue and harmonic tissue allowed better appreciation of the inflamed digestive wall stratification and the thickness of mucosa and submucosa (fig 4), comparative with simple hydrosonography (due to uniform increase in echogenicity by microbubbles). Information about peristaltic movements allowed in a patient to formulate the diagnosis of toxic megacolon. Instead, the use of phase inversion technique allowed a better identification of ulcerations by creating a strong

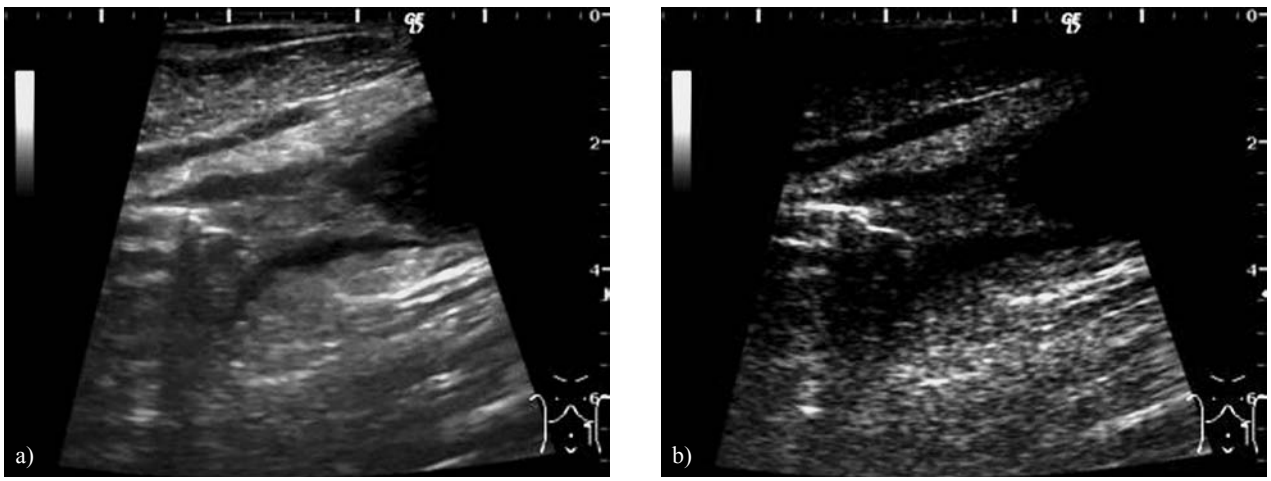


Fig 3. Contrast agent US optimized with SonoVue in a stenosing Crohn's disease of the descending colon: a) „harmonic tissue" technique- parietal thickening with loss of stratification and lumen narrowing; b) parietal thickening with loss of stratification. No ulceration is observed.

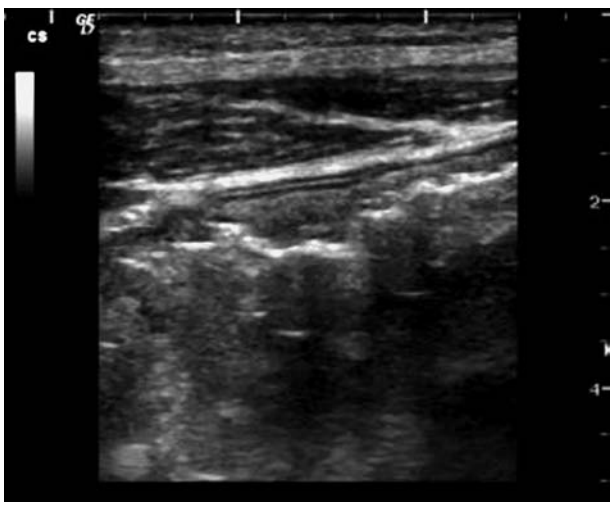


Fig 4. Contrast agent US optimized with SonoVue „harmonic tissue" technique, ulcerative colitis – better visualization of the lumen – mucosa interface. Thickening of mucosa and submucosa.



Fig 5. Contrast agent US optimized with SonoVue, „harmonic tissue" technique, transducer with a frequency of 9MHz – sigmoidian diverticula.

contrast between the lumen and mucosa, with accumulation of gas microbubbles on denuded areas.

In two patients with left colon tumors with improved ano-rectal CEUS evidence of localization and invasion into the digestive wall and adjacent structures of the tumor process waspermitted .

Two patients with sigmoid diverticulitis were examined using harmonic tissues after an enema with 1000 ml water and 1-2 drops of SonoVue. Due to the echogenicity of the lumen, identification of a focal disruption of the sigmoidian wall (fig 5) allows the identification of microperforations with paracolic extravasations of contrast agent. Monitoring the effectiveness of therapy is another indication of this method, being non-invasive and without radiation, and allowing the setting of the appropriate time to perform colonoscopy.

Rectum and anus. Examination with a contrast agent is a way to optimize endorectal ultrasound by realizing a „removal" of the region of interest from the transducer, facilitating the focalization of ultrasound. The endocavity transducer used has a 7 to 10 MHz frequency. The shape of transducer is important to obtain a quality image. For tumor staging a mechanical transducer is ideal (the uniform rotation provides 360° allowing the view of whole rectal circumference and the ultrasound beam having a perpendicular angle on the mucosa surface). In this way the „compression" of the wall with the transducer is avoided,

facilitating Doppler examination. The digestive surface is easier to examine; the ultrasound beam can be oriented perpendicular to it. Endocavity exploration using endovaginal approach enhances the diagnosis performance for tumor staging [28,29]. The main indication of the procedure is for staging rectal tumors. *Malignant tumors* have a large base of implantation, homogeneous structure, irregular surface, anfractuous, and increased vascular signal, with space disorder. Palpation with the transducer evidences an increasing tumor consistency and frequently highlights the tumor penetration in the rectal layers and adjacent organs [30]. *Benign tumors*, mainly villous adenoma, are a heterogeneous structure, with an irregular surface, large base of implantation but a well-defined vascular pedicle and making the emerging of vascular branches look relatively tidy. There is a disproportion between tumor size, often large, and the absence of deep rectal wall invasion, which is ongoing. The tumor is soft to palpation with the transducer. Rectal fistulas with adjacent tissues or organs are like paths with echogenicity, evidenced by the administration contrast agent with SonoVue, contained in a heterogeneous parenchymal mass, corresponding to reactive tissues. With the enhanced ano-rectal CEUS with SonoVue we have examined two patients with rectal tumors which permitted a proper staging.

Conclusions

Lumen ultrasound exploration with contrast agent of the digestive tract is a diagnosis procedure which assists the conventional method of examination. Ultrasound image is in „gray scale" and the additional information refers to the lumen. The selection of this procedure is conditioned by the specificity of the case and the need to obtain real information, not so credible within a routine examination. The method is limited by the situations where the patient is excessively overweight. An additional value is in cases where the details needed cannot be provided by conventional investigation. This category includes: a clear separation of mucosa surface and excellent view of the irregularities or erosion/exulcerations, an optimized image of the lumen and the report between the examined organ and the surrounding structures, an improved staging of malignant tumors by viewing the extension in the wall of the digestive tract and invasion into other organs.

Conflict of interest: none

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