Review paper

The role of intestinal ultrasound in diagnostics of bowel diseases

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Abstract

Intestinal ultrasound is a safe and inexpensive method that allows visualisation of the gastrointestinal tract and detection of abnormalities. This examination involves the use of two different ultrasound transducers: a low-frequency convex probe and high-frequency linear probe. When needed, the performance of these methods can be enhanced by the use of contrast media or Doppler techniques. Intestinal ultrasound is mostly utilised for the diagnosis and follow-up of patients with inflammatory bowel diseases, helping to avoid frequent use of invasive and expensive diagnostic procedures and leading to early implementation of suitable treatment. This technique can also serve to detect other pathologic conditions that are present in the gastrointestinal tract. It is a promising method with high sensitivity and specificity, which has gained popularity in recent years and has the potential to become the method of choice in the diagnostics of many intestinal disorders.

Introduction

Ultrasound examination is an easily accessible, non-invasive, radiation-free, and cheap imaging modality that is often chosen as the first diagnostic method in gastroenterology. Until recently, trans-abdominal ultrasound was rarely used for the assessment of the intestines due to difficulty of visualisation, impaired by the presence of gas and other intestinal content. Endoscopy, magnetic resonance imaging (MRI), computed tomography (CT), and conventional radiology were the preferred imaging methods in intestinal disorders. Over the past few years, thanks to technological progress in ultrasonography, followed by increasing experience of physicians, intestinal ultrasound has become an important diagnostic tool in the detection of bowel diseases. Being a safe, fast, inexpensive imaging method with high sensitivity and specificity, it is commonly used in European countries, such as Italy and Germany, especially for the diagnosis and monitoring of inflammatory bowel diseases (IBD) [1–6]. The performance of the intestinal ultrasound can be improved by the use of intraluminal or intravenous contrast media [4, 7, 8]. However, this method remains limited in many other countries, mostly because of lack of awareness and lack of expertise [9]. This technique is highly operator-dependent.

Ultrasound techniques

The machines used for sonographic evaluation of the gastrointestinal tract are no different than those used in standard radiology units. Nevertheless, the performance of intestinal ultrasound is dedicated to experienced sonographers, who are able to recognise and evaluate all bowel structures and their abnormalities [6, 10]. The performance of bowel ultrasound involves the use of two different probes: low-frequency convex probe (3.0–3.5 MHz) and high-frequency linear probe (5–17 MHz) [11]. First the abdomen is scanned by means of the convex low-frequency transducer, in order to visualise deeper structures and detect grossly abnormal pathologies, such as significant thickening of intestinal wall, bowel dilatation, and the presence of fistulae or abscesses. This is followed by a linear high-frequency transducer, for detailed evaluation of the intestinal wall,

which requires extra time and patience by the ultrasound operator [2, 9, 11].

The ultrasound examination should be performed preferably preprandially in the morning or after at least 4 h fasting, to reduce peristaltic movements and the amount of intraluminal air. The exception is emergency cases [11]. Patients undergoing this examination should also avoid laxatives and anti-flatulence medication prior to the procedure, in order to prevent false-positive and false-negative results [7]. Continuous, gradual compression of the intestines with the ultrasound transducer also helps to eliminate the air from the intestinal lumen, providing better visibility [5, 8, 11]. It also causes the compression of overlying soft tissues, bringing the transducer closer to the intestinal wall. What is important, the compression should be done carefully, without exceeding the pain experienced by physical examination [5, 8]. Healthy bowel is easy to compress [8].

The ultrasound conventional greyscale image allows the visualisation of the five layers of the bowel: the border between the lumen and mucous membrane – hyperechogenic, the mucous membrane – hypoechogenic, the submucous membrane – hyperechogenic, the muscle layer (or the muscle membrane proper) – hypoechogenic, the serous membrane – hyperechogenic [7, 8, 10, 12]. The main ultrasound criteria used in the evaluation of the bowel inflammation is the thickness of the intestinal wall, which according to different studies should be in normal condition up to 3–4 mm in the small intestine and up to 4–5 mm in the colon [2, 4, 7, 8, 12]. The thickening of the intestinal wall is present in many pathological conditions, such as: Crohn's disease, ulcerative colitis, intestinal ischaemia, neoplastic lesions, or amyloidosis [7, 8]. This finding is often accompanied by diminished compressibility of thickened bowel loops. The intestinal ultrasound examination also involves the assessment of the echogenicity of intestinal layers, haustration, intestinal motility, presence of perivisceral fluid, inflamed perivisceral fatty tissue, and enlarged mesenteric lymph nodes (> 10 mm in length) [5, 7, 12].

Other possible pathological findings include: conglomerates of loops, narrowing or dilatation of the lumen, and the presence of abscesses or fistulas [2].

The diagnostic potential of intestinal ultrasound examination can be improved by the use of contrast media that can be introduced orally, rectally, into fistulas, and intravenously [4, 5, 7, 12]. The most common of those methods is the use of an oral contrast agent, such as iso-osmolar polyethylene glycol solution (PEG). It is ingested at a volume 375–800 ml, generally no more than 500 ml. Polyethylene glycol solution oral administration is safe and well accepted by the patient [4]. Ultrasound sections of the bowel are done with the patient in a supine position, 10 min after oral administration of PEG solution, and then repeated at 10-minute intervals until the contrast is seen flowing through the terminal ileum reaching the caecum [13]. Application of this method improves the delineation of the bowel wall architecture, helps to distinguish one intestinal loop from another and to detect bowel lesions [11, 13, 14].

Doppler imaging techniques, such as colour Doppler or power Doppler, are tools that provide additional information about vascularisation of the inflamed bowel wall. Based on the intensity of colour signals and analysis of Doppler curves with measurement of resistivity index, the examiner can visualise and quantify intestinal wall vascularisation. Hyperdynamic splanchnic blood flow is characteristic for acute inflammation [11, 12, 15]. Although this method helps to distinguish inflamed and uninflamed parts of the bowel, it is not always suitable for the assessment of the severity of the disease. The limitation of these techniques is that they enable only the detection of larger vessels and do not provide sufficient information about microcirculation [12]. The use of Doppler techniques can also be applied for the differentiation of benign and malignant bowel lesions. The presence of neovascularisation is a hallmark of malignant tumour. Thus, application of this method could improve the diagnostics of intestinal neoplasms [15].

Contrast-enhanced ultrasound (CEUS) is a novel diagnostic tool that provides the visualisation of microperfusion in the intestinal wall. It involves intravenous administration of contrast agent with real-time examination, providing an accurate assessment of the bowel wall microvascularisation and the perienteric tissues [11, 12, 16–18]. Contrast-enhanced ultrasound is performed as a complementary diagnostic tool after identifying the inflamed area using Doppler techniques, for more detailed depiction of the microcirculation of small vessels. It is carried out with the use of high-frequency transducers. The contrast agents that are administered into the blood pool to enhance ultrasound signal contain gas microbubbles with a diameter of 2–6 µm, surrounded by a shell composed of lipids and polymers [12, 17].

Crohn's disease

In many European countries, intestinal ultrasound is becoming the first-line imaging method in patients with suspected inflammatory bowel disease, especially Crohn's disease (CD). This technique is also very useful as a fast and non-invasive tool for the supervision of already diagnosed patients, for periodic follow-up during treatment and for assessment after surgery [4, 17–22]. Many studies stress the importance of ultrasonographic bowel evaluation in CD. This method is gaining importance thanks to the development of technology and ris-

ing experience of sonographers. Intestinal ultrasound is said to be an accurate indicator of CD activity and bowel inflammation [5, 19, 20].

Crohn's disease is a chronic inflammatory process that involves all layers of the intestinal wall. It may affect any part of the gastrointestinal tract, although the most common location is the terminal ileum. In 30–40% of patients only the small intestine is affected (90% of which present with involvement of the terminal ileum) and 40–55% of the patients present with ileal and colonic localisation of the inflammation. Only 15–25% of the CD cases are restricted to the colon. Thus, in this condition an ultrasound examination should always involve a precise scanning of the ileocecal region. It should also include evaluation of the sigmoid colon, followed by assessment of the other parts of the colon and a search for disease landmarks in the remaining part of the small intestine [11].

The bowel wall affected by CD is thickened usually from 4 mm up to 15 mm with increased vascularisation. Power-Doppler and CEUS are good methods for determining the disease activity. Other pathological ultrasound features of CD are: stiffness of the intestinal wall, hyperechogenic reaction of the adipose tissue surrounding the intestine, diminished peristalsis of the small intestine, lack of haustration in the colon, and inflammatory infiltration around the affected part of the bowel. These findings are often accompanied by enlarged mesenteric lymph nodes in the affected areas. Intestinal ultrasound enables also the detection of possible complications of CD, such as: stenosis, perforation, abscesses, and fistulas. The application of CEUS enhances the performance of this technique and helps to distinguish abscesses from inflammatory infiltrations [4, 11, 17–19].

Ulcerative colitis

Ulcerative colitis (UC) is a chronic inflammatory process of the colonic mucous membrane. It is restricted the colon and does not affect other parts of the gastrointestinal tract. The inflammation has a predictable way of spreading in a continuous manner, from the distal to the proximal part of the colon. Depending on the range of the disease, it is classified into proctitis, left-sided colitis, or pancolitis (inflammation that exceeds beyond the splenic flexure). When the inflammatory process is restricted to the rectum, it cannot always be visualised because of the pelvic location [11].

Although the pathological process in UC is restricted to the mucosa, bowel wall thickening is also a characteristic ultrasound feature of this disease. However, bowel wall stratification is preserved in most of the patients due to the superficial pattern of the disease [11, 19].

The degree of the wall thickening depends on the disease severity and can be normal in the phase of remission [19, 23]. Thus, intestinal ultrasound is a good follow-up method during the clinical course of the disease, also used for evaluation of the response to therapy, and helps to avoid frequent endoscopies. Bowel wall thickening is frequently found in the left iliac fossa and, depending of the range of disease, it spreads continuously and regularly along the colon, in the proximal direction.

Other possible ultrasound findings in ulcerative colitis are: lack of haustration, enlarged mesenteric lymph nodes in the vicinity of the affected area, and the presence of pseudopolyps in the intestinal lumen. Toxic megacolon should be taken into consideration when the bowel wall is thinner than 2 mm and the lumen of transverse colon is wider than 6 cm [19, 23].

Many studies proved that intestinal ultrasound has similar sensitivity and specificity in the diagnostics of inflammatory bowel diseases compared to magnetic resonance and computed tomography [5, 6, 19, 20]. Thus, application of this method prevents patients from unnecessary radiation and shortens the waiting time for diagnostic procedures. Ultrasound evaluation of the gastrointestinal tract should also be the method of choice in patients with severe symptoms when colonoscopy is contraindicated or in cases when a fast examination is needed and access to other diagnostic tools is restricted [1–4, 6, 16, 19].

Appendicitis

An experienced examiner is able to detect acute appendicitis using ultrasonography with a specificity and sensitivity between 70% and 95% [19, 24]. A typical ultrasound landmark of acute appendicitis is a cord-like structure in the right iliac fossa, with no peristalsis, round shape of over 6 mm in diameter, often filled with liquid [19]. A disease with rapid progression and deep infiltration erases the layer structure of the intestinal wall, which is associated with high risk of perforation. Another sign of acute appendicitis is the presence of a faecal stone, which can be detected in ca. 33% of cases. Sonographic features of appendix perforation include focal decrease of echogenicity and the presence of liquid and gas next to the appendix. Abscess formation is the most common consequence of this complication [5, 7, 19, 24]. The power Doppler and colour Doppler techniques help to detect enhanced blood flow, which is also characteristic for inflamed appendix [19].

Diverticulosis and diverticulitis

Ultrasound of the gastrointestinal tract allows the visualisation even of uninflamed colon diverticula.

Although the detection of diverticula is more reliably done by CT, ultrasound is the preferred method in acute abdominal pain. Thus, it is important to be aware of sonographic features of diverticulitis [25].

The diverticula are described as "soap bubbles" along the intestinal wall, their typical feature is lack of muscle tissue. The most common location of diverticula is the sigmoid colon. Their inflammation (diverticulitis) is easy to detect by means of ultrasound techniques; it is depicted as a round hypoechogenic ring of variable thickness at the intestine, described also as "a symptom of dome" [5, 7]. Sigmoid diverticulitis is a common condition and the diagnosis can be also suggested by clinical signs and laboratory tests [25].

Possible complications that can be found in the ultrasound are: perforation of diverticulum, abscess, and inflammatory infiltration of the intestinal wall. Ultrasonography is the first-line imaging method in patients with suspected diverticulitis. It is decisive for the choice of treatment and prevents an unnecessary colonoscopy procedure that may lead to perforation in this condition [5, 7, 25].

Conclusions

Intestinal ultrasound is becoming a useful diagnostic tool for the early diagnosis and observation of the clinical course of many diseases of the gastrointestinal tract, some of which were specified above. Being a method of high sensitivity and specificity, it is also non-invasive, radiation-free, inexpensive and can be repeated many times. Its most common clinical applications include assessment of the activity and complications of IBD, being a good alternative for colonoscopy or magnetic resonance. However, it can be applied for the diagnostics and monitoring of many other conditions. The technical progress allows the use of ultrasound machines that provide very accurate imaging of all the gastrointestinal tract. However, this method is highly operator dependent and requires great experience. This is the reason why it is still underutilised in many countries due to lack of training centres. However, these methods are gaining popularity every year and hopefully will be available for application in every gastroenterology unit in the near future.

Conflict of interest

The authors declare no conflict of interest.

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