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Ultrasound of the gastrointestinal tract

Alois Hollerweger[1], Klaus Dirks[2]

[1]Department of Radiology, Hospital Barmherzige Brüder Salzburg, Austria

[2]Gastroenterology and Internal Medicine, Rems-Murr-Klinikum Winnenden, Germany.

Corresponding author:

Dr. Alois Hollerweger

Department of Radiology, Hospital Barmherzige Brüder, Kajetanerplatz 1, A-5010 Salzburg.

Tel +43 662 8088

alois.hollerweger@bbsalz.at

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Introduction

Over the past two decades ultrasound has gained increasing importance as a tool for diagnosis of different gastrointestinal (GI) diseases. Improvements in ultrasound technology and increasing familiarity with sonographic findings in a variety of GI disorders have widened its applications. The spectrum of indications not only includes acute conditions, such as appendicitis, diverticulitis and bowel obstruction, but also a number of subacute and chronic diseases.

The ability of ultrasound (similar to CT and MRI) to evaluate the transmural inflammatory or neoplastic changes within its surrounding structures is one of the major advantages over endoscopy and contrast radiography. This can contribute significantly to a correct diagnosis and to monitor disease activity. Ultrasound provides more detailed information on bowel wall layers than CT, it has a wider availability, is non-invasive and can be performed without preparation.

However, there are some relevant limitations to ultrasound: the alimentary tract, especially the small bowel, cannot be visualised continuously over its entire length; many of the findings are non-specific; obtaining and interpreting the images is highly operator dependent; image quality may be poor in obese patients, in whom scanning with high-frequency probes cannot be performed; overlying gas may hinder the demonstration of relevant structures; and technical influences such as depth penetration and colour Doppler sensitivity.

Technical considerations

Imaging of the alimentary tract requires not only abdominal probes (1-6 MHz) but also high-frequency linear or convex probes (5-15 MHz). Tissue harmonic imaging allows better delineation of wall layers. Modern technical equipment includes colour and power Doppler imaging. The use of colour Doppler imaging has been described in a variety of GI disorders, particularly in patients with Crohn's disease, ischaemic disease and coeliac disease. Information regarding the main mesenteric vessels (systolic and diastolic velocities, and resistance index) combined with information on end-organ vascularity in the affected segments of the GI tract may contribute to a correct diagnosis. Panoramic imaging may also be useful in visualisation of longer portions of the intestine.

Contrast-enhanced ultrasound (CEUS) has been introduced in the last years and has found its place in specific GI problems [1]. Low mechanical index and second-generation microbubble contrast agents enable visualisation of vascularity in a few minutes. Differentiation of inflammatory disease from ischaemic disease and scar tissue, or better delineation of abscess formations are both possible applications for this new modality. Quantification software tools allow to characterise inflammatory activity and treatment efficacy in inflammatory bowel disease. Oral application of diluted ultrasound contrast agent or injection in orifices for visualisation of the course of a fistula are further uses of this method.

Elastography is a new method to assess noninvasively the stiffness of different tissues. Clinical research focuses on characterisation of focal bowel wall lesions and on differentiation of inflammatory from fibrotic stenosis [2].

Transrectal and transvaginal ultrasound can be used to complement transabdominal ultrasound for the evaluation of different intestinal diseases in the small pelvis. High-frequency probes allow excellent visualisation of this region. Perineal ultrasound is another technique that can provide detailed information about perianal structures. This approach is particularly helpful in the initial evaluation of patients with perianal fistulas.

Anatomy and normal appearance of the gastrointestinal tract

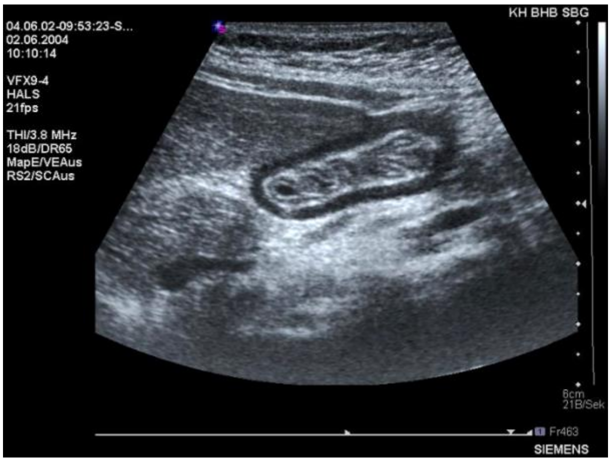
Wall thickness of the alimentary tract differs from part to part, and depends largely on the state of distension or contraction. Under normal conditions stomach thickness measures 3-6 mm; small bowel, 1-3 mm; and colon, 0,5-4 mm. A contracted intestinal segment should not be misinterpreted as a thickened wall.

High-resolution transducers usually allow the visualisation of five concentric layers of normal gastric or bowel wall [Figure 1]. Various experimental studies have shown that the five layers on sonographic images closely correspond to the histological layers of the wall [3-5]:

- outer hyperechoic layer: serosa and interface to the serosa;
- outer hypoechoic layer: muscularis propria;
- middle hyperechoic layer: submucosa;
- inner hypoechoic layer: mucosa; and
- inner hyperechoic layer: superficial mucosal interface.

**Figure 1	Gastric wall layers. Cross section (a) and zoomed longitudinal section of the gastric antrum show the different wall layers (b). sif, serosal interface; mp, muscularis propria; sm, submucosa; m, mucosa; mif, mucosal interface; l, lumen.**

a



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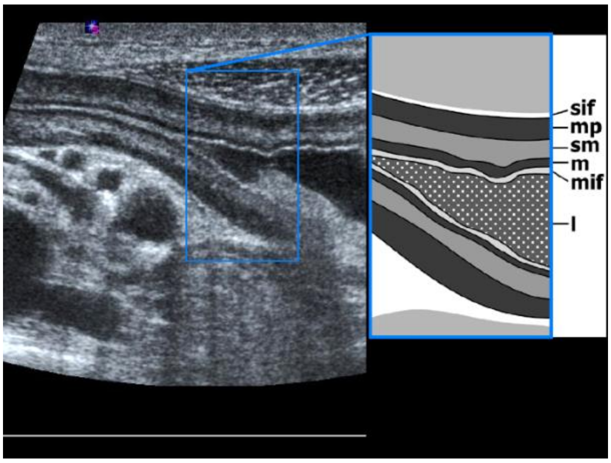
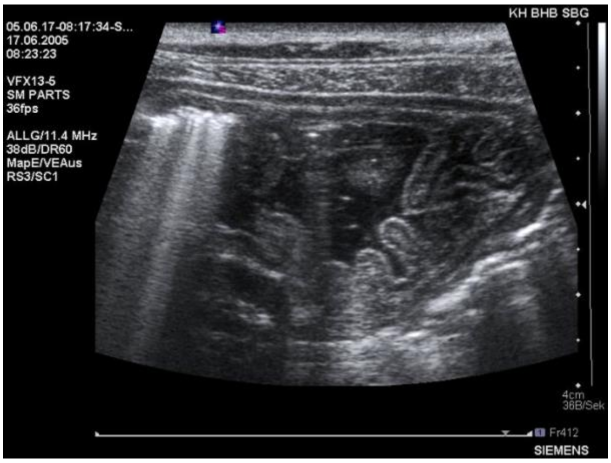


The different gut parts can be identified by their topographical position and specific morphological criteria. The muscular layer of the stomach, especially that of the antrum, is more pronounced than in other parts of the intestine. In a non-distended condition, the mucosal folds of the gastric corpus and fundus are well-demonstrated [Figure 2a]. The valvulae conniventes are typical of the small intestine; they decrease in number and height from the proximal jejunum to the distal ileum and are best visualised when the bowel loops are fluid filled [Figure 2b]. The colon is characterised by its haustration, which is best visible on ultrasound at the ascending and transverse colon [Figure 2c]. The left hemicolon is sometimes seen in a contracted condition.

Figure 2 **Stomach (a). Cross-section of the gastric corpus with mucosal folds protruding into the lumen. Small bowel (b). Longitudinal section of a jejunal segment showing the numerous valvulae conniventes. Colon (c). Longitudinal scan of the ascending colon with typical haustration.**

a



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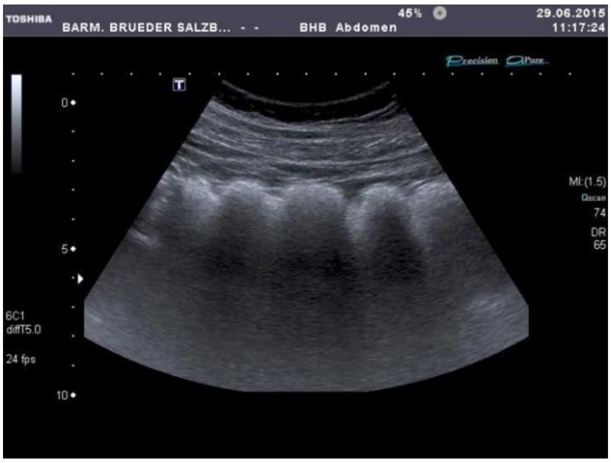
c



Certain gut parts, such as the cardia, gastric antrum, duodenum, ileocecal region, and ascending and descending colon can be routinely displayed. The rectum, lower sigmoid colon and left colonic flexure cannot always be shown satisfactorily and the small bowel cannot be scanned continuously.

Three main visceral arteries supply the GI tract: the coeliac trunk, the superior mesenteric artery and the inferior mesenteric artery. Arteries, veins, nerves, and lymphatics run in the mesentery to and from the bowel segments.

Wall-thickness, stratification, echogenicity, length of the affected segment, luminal width, vascularization, peristalsis and associated findings in adjacent tissue are all sonographic criteria taken into consideration when making a diagnosis.

Examination technique

Examination of the GI tract usually starts with a systemic survey using an abdominal probe to provide an overview over the different parts of the GI tract. Subsequently, examination continues with a high-frequency probe to obtain detail and focus on the actual problem [6]. In patients with localised abdominal pain the examination can initially be focused on this area. Standardised evaluation should optimally take place after overnight fasting; however, this is not a pre-condition in urgent situations. To avoid interfering bowel gas in cases of bowel obstruction, assessment of the abdomen from a more lateral aspect through both flanks is recommended.

The stomach is scanned in longitudinal and transverse sections via a subxiphoidal approach from the cardia to the pylorus. Using the left liver lobe as an acoustic window, provided conditions are good, it is possible to scan the distal oesophagus by tilting the probe cranially in the epigastrium. The fundus of the stomach can be demonstrated in a transsplenic view. The duodenum is identified by its “C-shaped” course around the pancreatic head and by the location of the third part of the duodenum, which lies between the aorta and the superior mesenteric vessels [Figure 3a].

The small bowel cannot be evaluated continuously; therefore, systemic examination is performed by making vertical, parallel and overlapping lanes with the transducer. The jejunum is usually located in the left upper- and mid-abdomen, and the ileum in the right mid- and lower abdomen. The right iliac vessels are a landmark of the ileocaecal region. Fluid-filled small bowel loops allow optimal visualisation of the valvulae conniventes [Figure 3b].

It is important to scan the colon systematically and this is usually performed in transverse sections for each segment. First, the ascending colon is identified in the right upper quadrant and followed downwards to the caecum and this can be done in reverse. The colon is then followed from the right colonic flexure along the transverse colon to the splenic flexure. The descending colon is identified by its laterodorsal position and scanned caudally to the sigmoid colon, which takes a variable course over the left iliac vessels to the small pelvis. The rectum is visualised through the filled bladder [Figure 3c] [7, 8].

Assessment of the GI tract is usually performed with the graded compression technique. Interfering bowel loops and gas are then displaced and probes with higher frequency can be used, which allows for a more detailed view of the bowel wall and surrounding structures.

Figure 3 **Examination technique of the upper gastrointestinal tract (a). The stomach and the duodenum can be scanned by standardised longitudinal and transverse sections through the upper abdomen. 1, cardia; 2, antrum and corpus of the stomach; 3, pars descendens duodeni; 4, pars horzontalis inferior and pars ascendens duodeni; 5, transsplenic view of the fundus. Examination technique of the small bowel (b). The small bowel is scanned systematically by parallel overlapping lanes (like “mowing the lawn”). The terminal ileum can be demonstrated on its course over the psoas muscle and**

the iliac vessels. Examination technique of the large bowel is shown in (c). Systematic examination is usually performed in cross-sections of the colonic segments. 1, ascending colon to the caecum; 2, transverse colon from the right to the left colonic flexure; 3, descending colon to the sigmoid colon and rectum

a