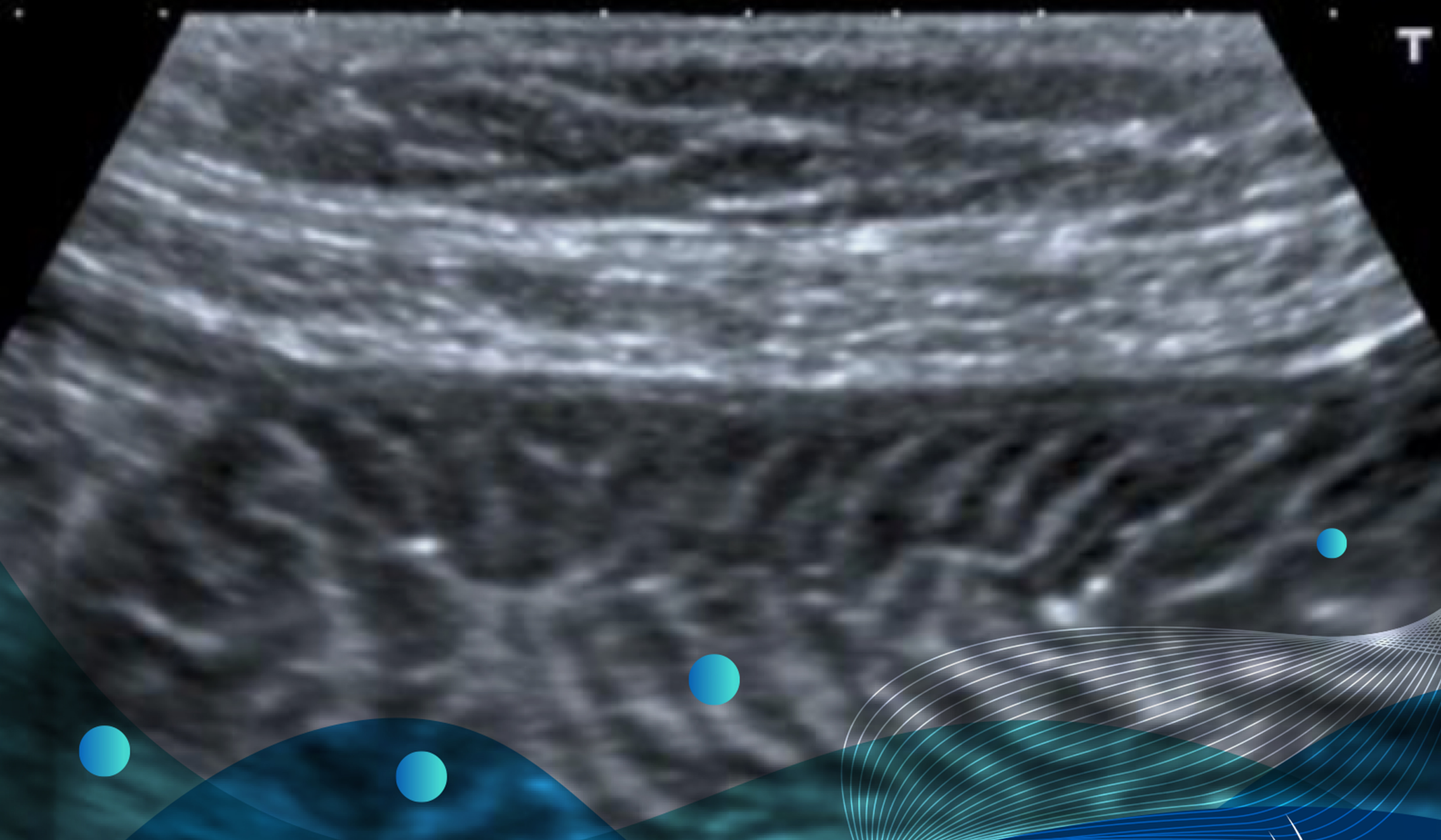

EFSUMB Course Book

2nd Edition

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Ch15: Ultrasound of the gastrointestinal tract

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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.**

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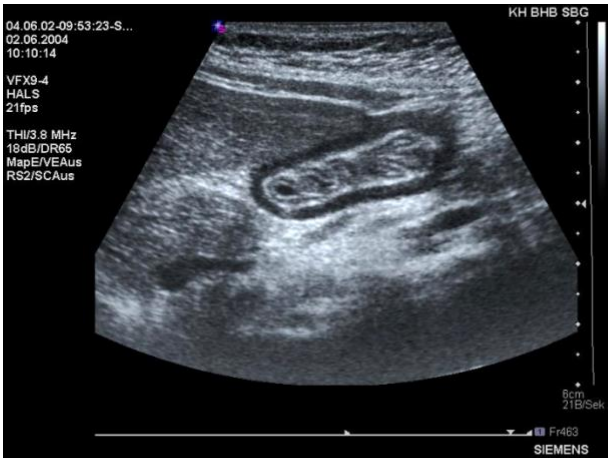

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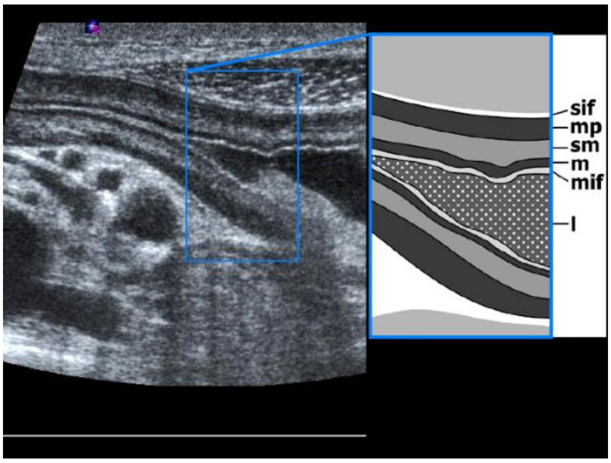

The different gut parts can be identified by their topographical position and specific morphological criteria. The muscular layer of the stomach, especially that of the antrum, is more pronounced than in other parts of the intestine. In a non-distended condition, the mucosal folds of the gastric corpus 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.**

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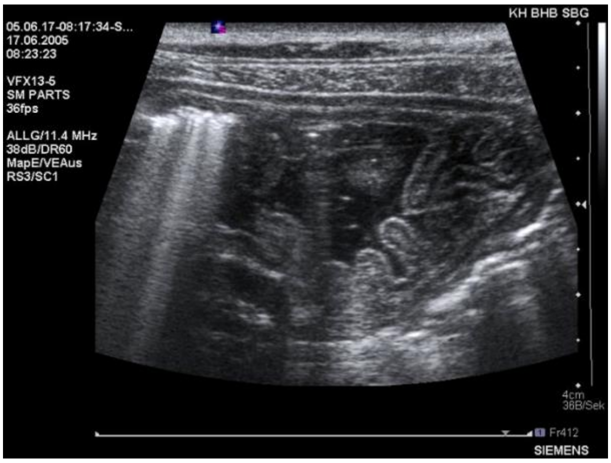

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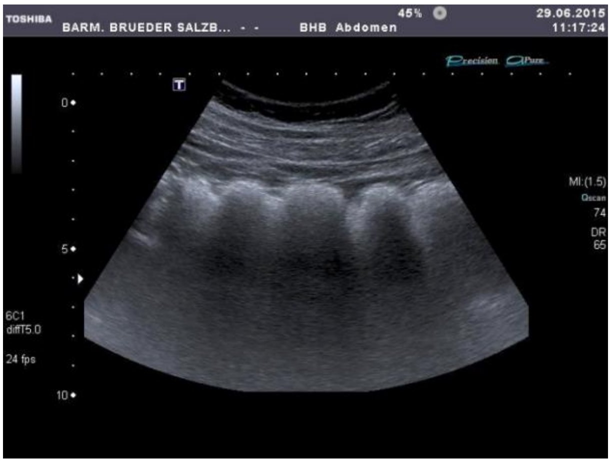

Certain gut parts, such as the cardia, gastric antrum, duodenum, ileocecal region, and ascending and descending colon can be routinely displayed. The rectum, lower sigmoid colon and left colonic flexure cannot always be shown satisfactorily and the small bowel cannot be scanned continuously.

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

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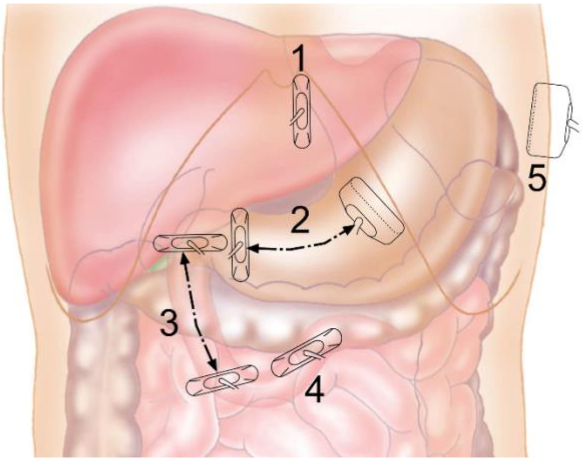

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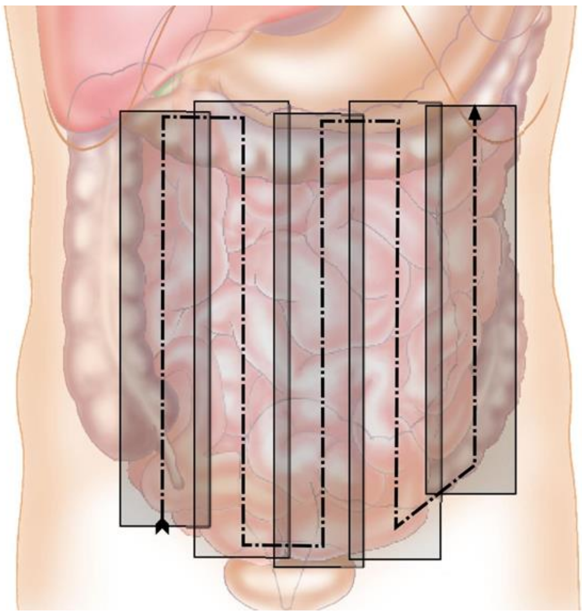

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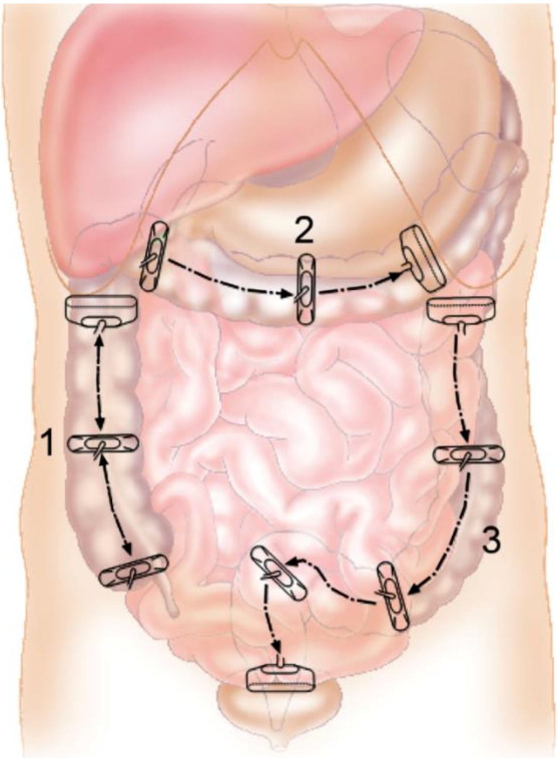

Appendicitis

Acute appendicitis is the most common reason for acute surgery in Western countries [10-12]. Only 50–60% of patients present with typical clinical symptoms, which means appendicitis is a common clinical problem. Children and adolescents are most often affected. Without the use of imaging methods, the incidence of negative laparotomies may be up to 45%, especially in women of childbearing age [11, 13-15].

The appendix is a blind-ending, tubular structure that arises from the caecum. The normal appendix has different wall layers similar to the rest of the intestine, it frequently courses from the iliac fossa medial and caudal over the iliopsoas muscle, is oval shaped under compression and contains some gas or faecal material. However, the position of the appendix can vary, it may continue in different directions or even retrocaecally; the caecum can also have a variable position.

Appendicitis is often triggered by luminal obstruction owing to infectious swelling of the wall, faecaliths, lymphatic hyperplasia, food remnants and other rare causes. An increase in intraluminal pressure, tissue damage and pathogen entry into the appendiceal wall can lead to transmural inflammation. The most important sonographic criteria of acute appendicitis are [16-18]:

- A non-compressible appendix with a diameter >6 mm. The wall is either thickened by the acute inflammation or the lumen is distended and filled with purulent content. Initially the wall layers are preserved, but the more the inflammation extends, the more the layers are destroyed [Figure 4].
- A Point of maximum tenderness over the appendix.
- Hyperechoic changes to the surrounding fatty tissue and loss of compressibility. In more severe cases hypoechoic changes and fibrinopurulent exudate may be visible. Adjacent bowel loops, such as the caecum and terminal ileum are often involved and thickened.

Figure 4 **Appendicitis. Longitudinal view of the thickened appendix (a). The wall layers are visible, but the hyperechoic submucosa is partly disrupted in this case of phlegmonous appendicitis. On the transverse view the appendix is visible twice owing to its winding course (b). This scan also demonstrates the inflammatory changes of the peri-appendiceal mesenteric and omental fat (arrows) better. In another case (c) no significant wall thickening is present but the lumen is distended and filled with purulent content. The markers show the diameter of the dilated appendix.**

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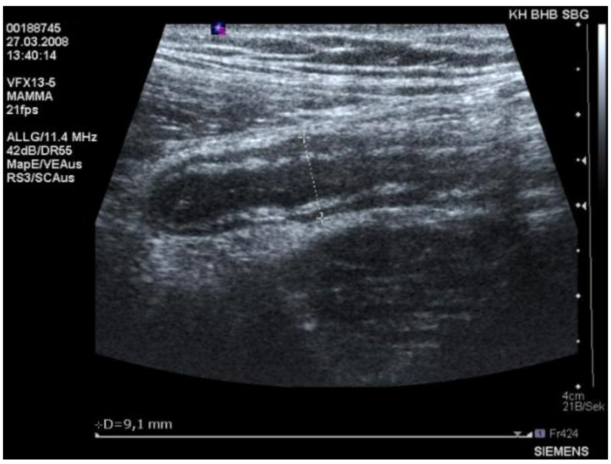

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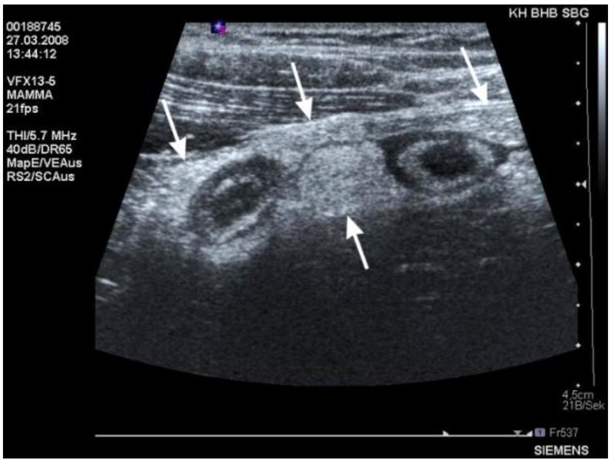

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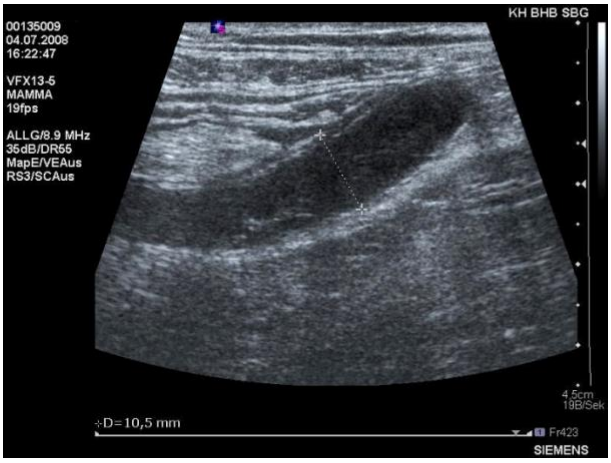

In the case of a perforated appendix the appendiceal wall is at least partly destroyed and signs of local peritonitis are present. If a perityphlitic abscess forms, retention of mixed echogenicity with or without gas bubbles can be demonstrated. Free intraperitoneal gas is only rarely seen [Figure 5].

The most common causes of false-negative sonographic results are because only the tip of the appendix is inflamed, an atypical appendiceal position (small pelvis, retrocaecal), a gangrenous gas-filled appendix or a perforated non-identifiable appendix.

In obese patients in whom suspicion of appendicitis is high, CT is the next step if ultrasound is unable to identify the appendix. MRI is an alternative method in young patients and pregnant women.

The most important differential diagnoses of acute appendicitis include inflammatory diseases of the bowel, various gynaecological and urological diseases, perforated caecal carcinoma, omental infarction as well as a number of rare findings [20-22]. Some acute conditions of the abdominal wall and of the retroperitoneum, such as an incarcerated hernia or a haematoma of the psoas muscle, may also mimic appendicitis.

Figure 5 **Perforated appendix. A hypoechoic fluid collection with gas bubbles representing a perityphlitic abscess (a) is visible in the right lower quadrant just behind the thickened caecum (arrows). The appendix was almost completely destroyed. In the second case (b) the proximal part of the appendix is well-delineated whereas the distal part is destroyed (arrows) due to perforation at the tip of the appendix.**

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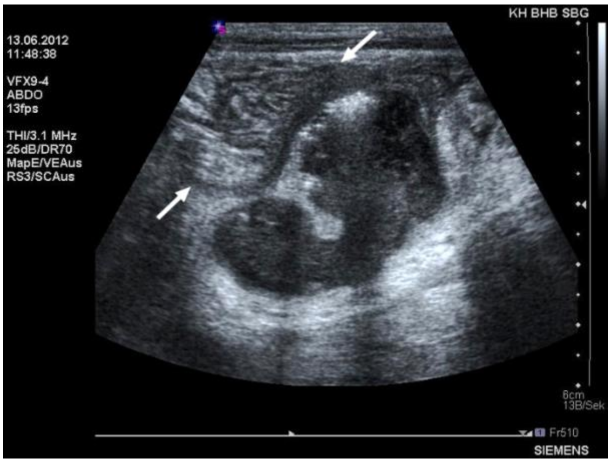

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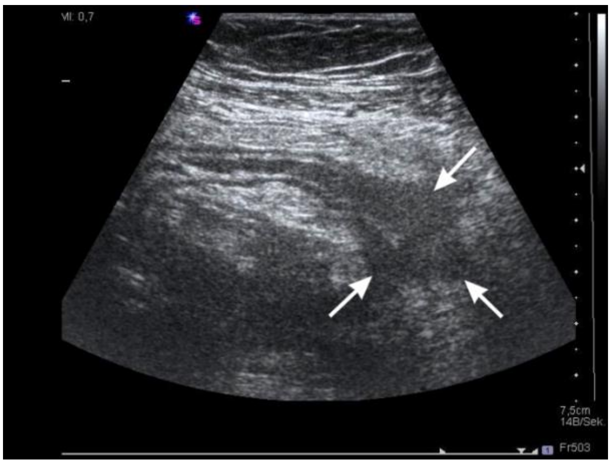


Diverticulitis

Diverticulitis is a common cause of left lower quadrant pain and the frequency is increasing. Almost all clinically significant cases of diverticulitis are a result of microperforation of the thin-walled pseudodiverticula, which are predominantly located in the sigmoid colon.
Ultrasound and CT are the imaging methods of choice as inflammation primarily involves the pericolic structures, particularly the fatty tissue of the mesocolon and epiploic appendages [23-26].
The presence of the following criteria at the point of maximum tenderness allows a specific sonographic diagnosis of diverticulitis [24, 27] [Figure 6]:

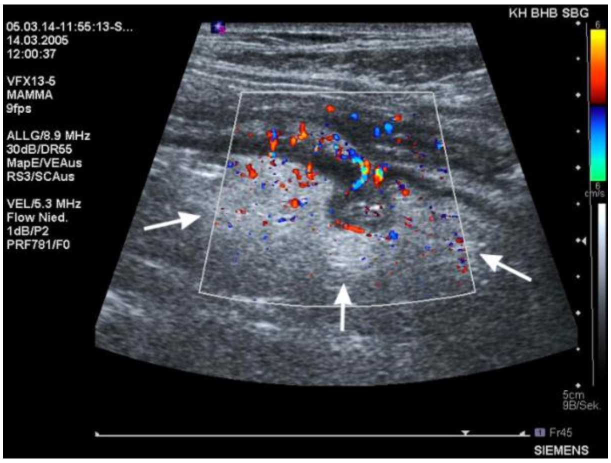
- Short segmental bowel-wall thickening: the bowel wall layers are usually preserved and hypertrophy of the muscular layer is frequently seen.
- Alteration of the pericolic fat: ranging from hyperechoic non-compressible fat to hypoechoic phlegmonous inflammation with fibrinopurulent exudate.
- Demonstration of the inflamed diverticulum: in contrast to normal diverticula they are hypoechoic or hyperechoic with a hypoechoic rim and are surrounded by hyperechoic fatty tissue.

Right-sided diverticulitis tends to occur in younger patients and is more frequent in Asia. The sonographic signs are identical to those of left-sided diverticulitis and ultrasound usually permits differentiation from acute appendicitis.
The lower sigmoid colon is difficult to assess by transabdominal ultrasound. Additional transvaginal ultrasound or transrectal ultrasound provides relevant information on abnormalities in this segment in 10-20% of patients [28].

Figure 6 **Sigmoid diverticulitis. This transverse scan (a) of the sigmoid colon shows all typical criteria of diverticulitis. The wall layers of the thickened colonic wall are preserved. The inflamed diverticulum contains a faecalith and is surrounded by a hypoechoic rim and hyperechoic fatty tissue (arrows). Colour Doppler imaging in another patient (b) demonstrates hypervascularity in the colonic wall, diverticulum wall and in the inflamed peridiverticular fat (arrows).**

a

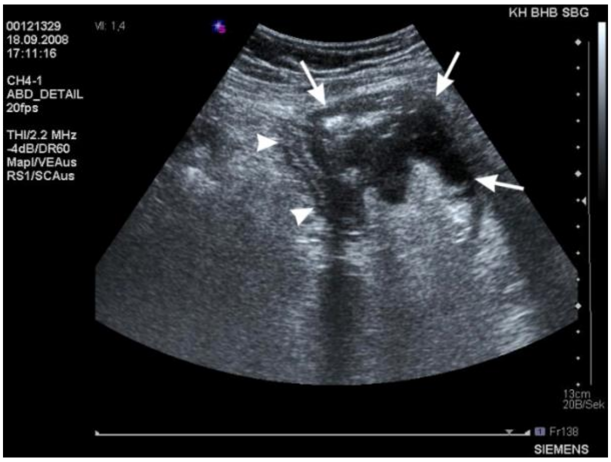
b



The typical complications of diverticulitis include abscess formation, fistulas, perforation and stenosis. Hypoechoic abscesses are usually easily detectable with ultrasound whereas predominantly hyperechoic, gas-containing abscesses are sometimes difficult to differentiate from bowel loops [Figure 7]. In this case, where there are discrepancies between the clinical signs and sonographic results, CT should be performed. Fistulas may present as hypoechoic bands with central gas bubbles. Gas in the urinary bladder is a frequent indirect sign of a sigmoid-vesical fistula. The typical signs of perforation are described in the section on perforation.

Differential diagnoses of diverticulitis include epiploic appendagitis, ischaemic colitis, bowel obstruction, penetrating or perforated sigmoid cancer, sigmoid volvulus, left sided ureteral calculus, torsion of adnexal masses, and acute conditions of the abdominal wall or retroperitoneum.

Figure 7 **Peridiverticular abscess. This complex gas-containing lesion (arrows) adjacent to the sigmoid colon (arrowheads) represents a peridiverticular abscess.**



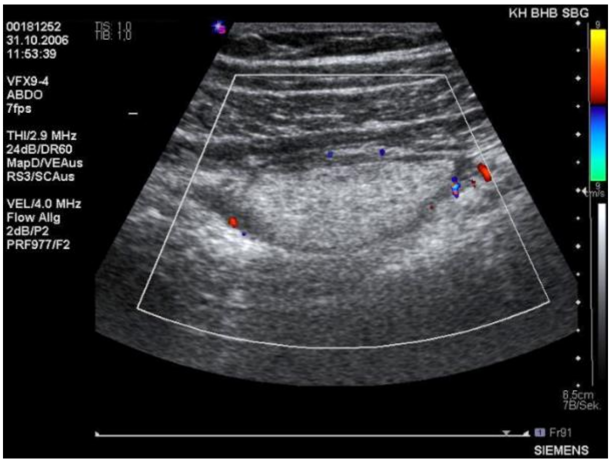
Intraabdominal focal fat infarction

Omental infarction and epiploic appendagitis can be summarised by the term “intra-abdominal focal fat infarction” [22]. Ultrasound and CT features provide a reliable diagnosis. Both conditions occur more frequently than generally assumed and sometimes discrimination of omental infarction and epiploic appendagitis with certainty is not possible. Both omental infarction and epiploic appendagitis are self-limiting conditions, and correct diagnosis avoids unnecessary laparotomy.

Segmental omental infarction results from either venous thrombosis or torsion of a portion of the omentum usually located in the right upper or lower quadrant. Ultrasound shows a hyperechoic non-compressible intra-abdominal mass, which usually adheres to the parietal peritoneum [Figure 8]. However, in contrast to epiploic appendagitis, the mass is larger and central hypoechoic areas are more common.

Figure 8 **Omental infarction. A hyperechoic non-compressible mass is shown in the right lower quadrant on this ultrasound scan. Colour flow is only visible in the**

peripheral zone of this segmental infarction of the omentum. The mass adheres to the peritoneum of the anterior abdominal wall.



Epiploic appendagitis is one differential diagnosis of diverticulitis. Infarction of an epiploic appendage is generally located in one of the lower quadrants, and more frequently on the left-side than on the right. At the point of maximum tenderness ultrasound shows a moderately hyperechoic, ovoid, and non-compressible mass directly under the abdominal wall that frequently adheres to the parietal peritoneum [29, 30]. The mass may be surrounded by a hypoechoic rim and bowel-wall thickening is usually absent. On colour Doppler ultrasound or CEUS the central necrotic appendage is avascular whereas the surrounding fatty tissue shows moderate hypervascularity [30].

Bowel obstruction

Patients with clinical signs of bowel obstruction, such as abdominal pain, abdominal distension and vomiting need immediate diagnostic evaluation. Currently simple radiographs are, for the most part, replaced by ultrasound and CT [31]. These methods allow for the earlier detection of bowel obstruction and for the detection of complications that need immediate surgery. The cause of obstruction can then be partially demonstrated and alternative diagnosis established. The level of obstruction can be determined by careful analysis of dilated bowel segments [31]. The duodenum can be seen next to the pancreatic head and the third part is recognised because it passes to the left side and is posterior to the superior mesenteric vessels. The dilated jejunum can be distinguished from the ileum by the pattern of the valvulae conniventes and, to a certain degree, the location in the abdomen. The colon is characterised by its typical haustration. Moreover, the ascending and descending colon are fixed to the retroperitoneum laterodorsally in the abdominal cavity.

Gastric outlet and duodenal obstruction

Chronic duodenal ulcer and tumours of the stomach or the pancreatic head are the most common causes of upper GI obstruction. Plain radiographs are frequently false-negative in these cases because vomiting results in a lack of air in the obstructed segment. Ultrasound can easily depict the dilated stomach with ingested food and fluid-fluid levels [Figure 9]. The dilated duodenum or the dilated segment in an afferent-loop syndrome is also reliably demonstrated. Delayed gastric emptying may also be caused by inadequate peristalsis owing to a number of diseases [32].

Figure 9 **Upper gastrointestinal obstruction. Ultrasound image shows dilatation of the stomach with a fluid-fluid level. The cause of obstruction is visible just behind the antrum. A metastatic lesion of the upper jejunum (not shown) led to an intussusception.**

Small bowel obstruction

Approximately two thirds of small bowel obstructions are caused by adhesions. In this situation there is usually no visible abnormality at the point of transition from dilated bowel to normal bowel. Other reasons of small bowel obstruction, such as tumours, hernias, Crohn's disease, bezoars, or a perforated gallstone [Figure 10c] can be demonstrated on ultrasound [33].

Small bowel obstruction must be considered to be present when:

- the lumen of the fluid-filled small bowel loops is ≥3 cm;
- peristalsis of the dilated segment is increased;
- bowel loops distal to the stenosis are collapsed.

A small amount of intraperitoneal fluid is frequently present [Figure 10]. Difficulties may arise when the obstruction becomes prolonged and the dilated segment becomes paralytic. This situation should not be mistaken for paralytic ileus. Contracted bowel loops distal to the stenosis still allow for correct diagnosis.

An akinetic dilated bowel loop, thickening of the bowel wall and the leaves of the mesentery, and increased intraperitoneal fluid are suspicious of strangulation requiring immediate surgery. Closed-loop obstruction with a typical omega-shaped distended loop or a conglomerate of fluid-filled loops is a situation in which strangulation frequently occurs.

Figure 10 **Small bowel obstruction. Cross section in the left mid-abdomen shows dilated fluid-filled small-bowel loops and the contracted descending colon (black arrow) (a). Free fluid in the peritoneal cavity (white arrows in a and b) is also present. The numerous valvulae conniventes protruding to the dilated lumen are characteristic for the jejunum (b). Gallstone ileus (c). Obstruction in this case was caused by a large gallstone visible in the lumen of the small bowel.**

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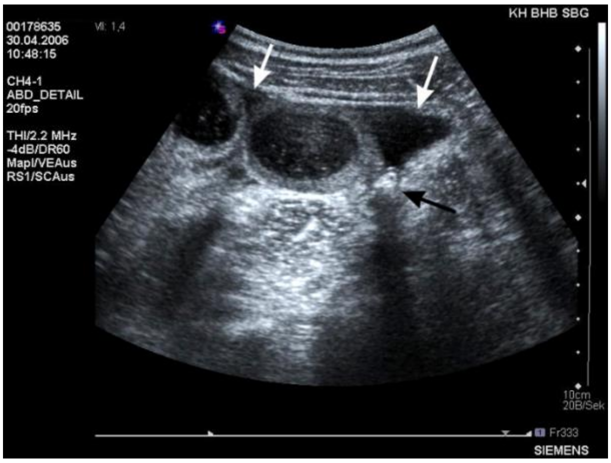
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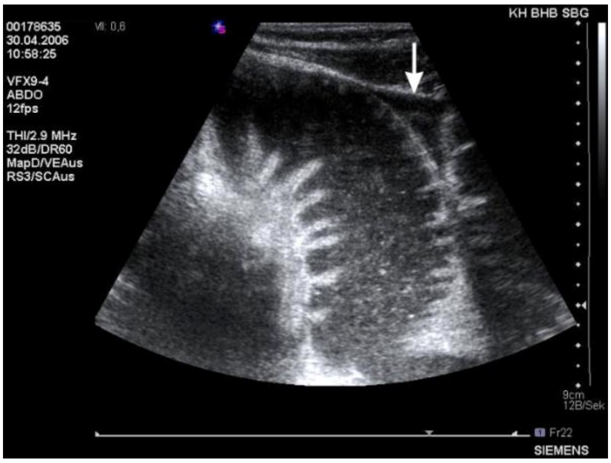
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Large bowel obstruction

Tumours of the colon are the most common cause of large bowel obstruction. Other causes include volvulus, inflammation and scar shrinkage owing to inflammation or ischaemia. Ultrasound shows a dilated colon with usually hyperechoic content [Figure 11]. Owing to the disturbance of gas it is sometimes difficult to get a clear overview and determine the site of stenosis [34, 35]. In this situation CT would be the next method in establishing a correct diagnosis.

Figure 11 **Large bowel obstruction. The descending colon is dilated and filled with faeces and gas (a). Massive dilatation and obscuring gas can hinder adequate evaluation of the underlying cause. A carcinoma of the sigmoid colon (arrows) with a stenotic irregular lumen was the cause of the obstruction in this patient (b).**

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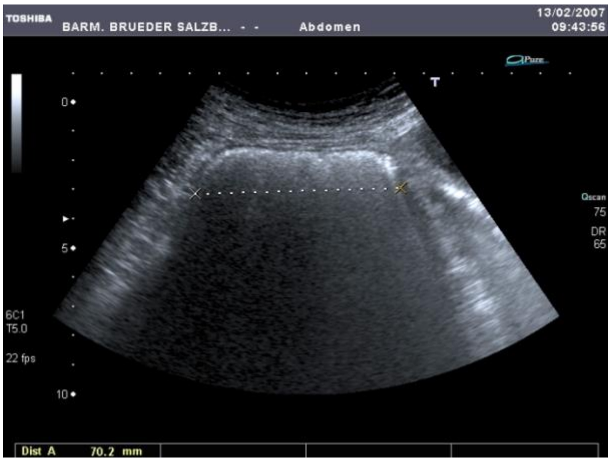

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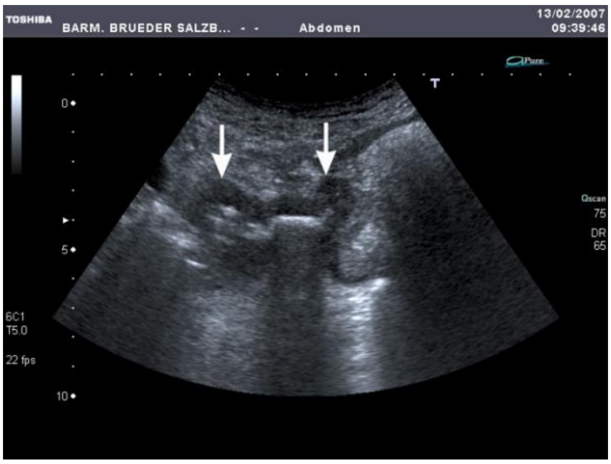


Bowel obstruction must be differentiated from paralytic ileus [Figure 12] and other conditions leading to dilatation of the lumen. In paralytic ileus usually both the small bowel and the large bowel are dilated and peristalsis is reduced. Stool impaction in elderly and bedridden patients is also an important differential diagnosis.

Figure 12 **Paralytic ileus. Numerous fluid-filled, dilated and aperistaltic small bowel loops are visible in this patient after caesarean section. The large bowel (not shown) was also dilated and partly fluid-filled.**

Perforation

The detection of gas in the peritoneal cavity is a clue to the diagnosis of perforation of the alimentary tract. Ultrasound is more sensitive than plain film for diagnosis of pneumoperitoneum or pneumoretroperitoneum, but CT is the most accurate method.
Ultrasound displays pneumoperitoneum as a hyperechoic line or as small gas bubbles with reverberation artefacts between the visceral and the parietal peritoneum. This is best visualised anterior to the liver surface or immediately below the anterior abdominal wall in the supine position or left decubitus position [36-38]. Extraluminal gas moves by changing the patient's position and disappears when increasing pressure is applied [Figure 13]. Similar to

plain film, after changing the patient's position a short time-frame may occur before small amounts of gas move to typical areas and become visible on sonograms.

Pneumoperitoneum and extraluminal fluid are demonstrable in the upper abdomen as a consequence of gastric or duodenal perforation. The most common causes are perforated gastric or duodenal ulcers. Evidence of gas in the fissure for ligamentum teres is a further hint and may be the single sign in cases of contained perforation. If perforation of the small bowel occurs, extraluminal fluid with bright echoes and extraluminal gas are the predominant signs. Some of the reasons include perforated foreign bodies, ischaemic disease (gangrene) and blunt trauma.

Pneumoperitoneum is the predominant sign in colonic perforation; two-thirds of cases occur as a result of diverticulitis. Other causes include colonic ischaemia, bowel obstruction, perforated neoplasms or iatrogenic perforation. Contained perforation to the mesosigma in diverticulitis can easily be overlooked if the investigator is not familiar with the signs. In this situation extraluminal gas is often misinterpreted as luminal content in a bowel loop. CT would be the next diagnostic step if sonographic results remain unclear or clinical presentation is discrepant to the sonographic findings. Retroperitoneal perforation with pneumoretroperitoneum obscures retroperitoneal vessels and organs [Figure 14]. In the upper abdomen the duodenum is the typical location of retroperitoneal perforation and is primarily caused by a perforated duodenal ulcer or an endoscopic sphincterotomy. Most cases in the lower abdomen are due to perforated sigmoid diverticulitis or iatrogenic injury from endoscopy or postsurgical dehiscence.

Figure 13 **Perforation. A small gas collection anterior to the left liver lobe is a typical sign of gastrointestinal perforation (a). A gas collection in the peritoneal cavity is clearly shown in this image (b). The ascites allows optimal delineation of the peritoneal space. Slight thickening of bowel loops is also present.**

a

b

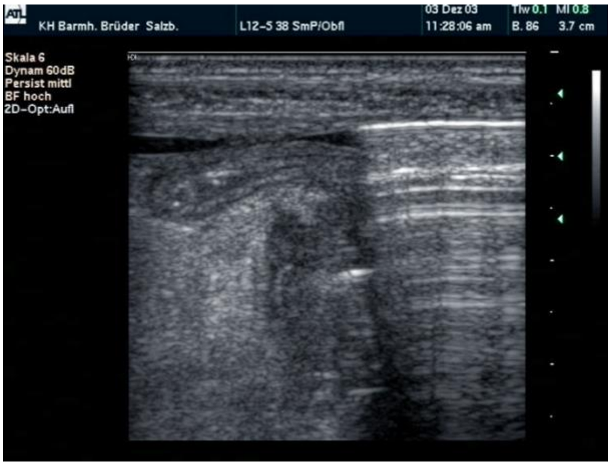
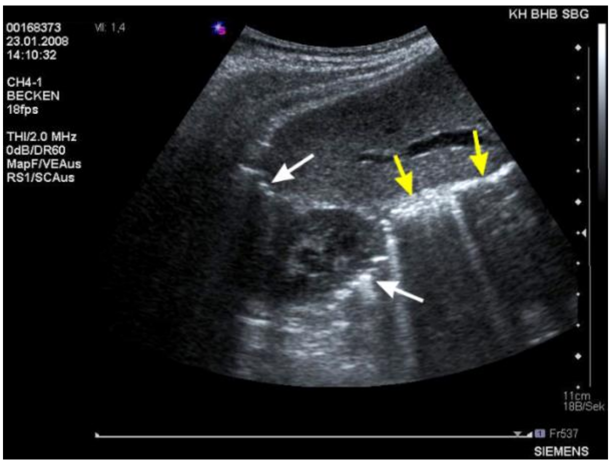


Figure 14 **Retroperitoneal perforation. The large amount of gas bubbles around the right kidney (arrows) and gas collections obscuring the large retroperitoneal vessels (yellow arrows) are typical of a retroperitoneal perforation.**



Infectious enterocolitis

Infectious enterocolitis is usually a self-limiting disease caused by a number of microorganisms. Diagnosis is confirmed clinically and on the basis of stool analysis. However, ultrasound can be helpful in assessing the extent of disease by narrowing the differential diagnoses in atypical cases and allowing for earlier treatment of severe colitis, which consequently prevents the development of serious life-threatening conditions for the patient. Simple **enteritis** is characterised by increased fluid in the small bowel and hyperperistalsis. In contrast to small bowel obstruction, width of bowel loops is within the normal limit (< 25mm). The colon is often visible in a contracted condition, but significant wall thickening is usually absent.

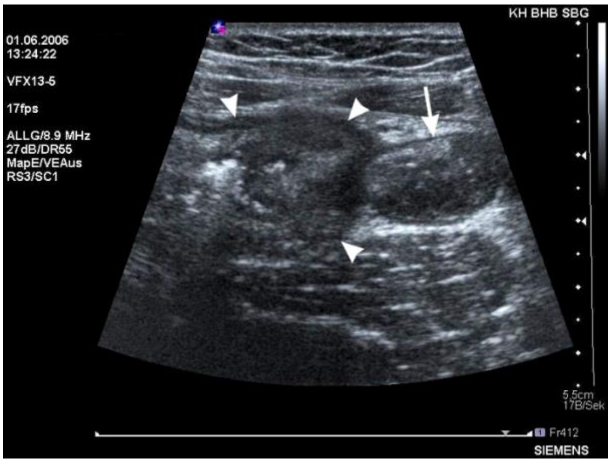
Infectious enterocolitis predominantly affects the right colon, it less frequently affects the left colon or manifests as pancolitis. A longitudinal view of the colon shows the typical haustration pattern. The mucosa and the submucosa are thickened but stratification is preserved and inflammation is limited to the colon [Figure 15]. Colour Doppler ultrasound demonstrates increased vascularity. Sonographic appearance of different types of colitis shows considerable overlap so that a specific diagnosis cannot be established.

Some pathological microorganisms such as Yersinia, Campylobacter and Salmonella may also specifically infect the ileocaecal region which is known as **infectious ileocaecitis**. The typical US findings are a symmetrical thickening of the terminal ileum and the caecum confined to the mucosa and submucosa and enlarged mesenteric lymph nodes in the ileocaecal region [Figure 16]. Correct ultrasound diagnosis can prevent unnecessary surgery for the patient if pain is the predominate symptom in such cases [39, 40].

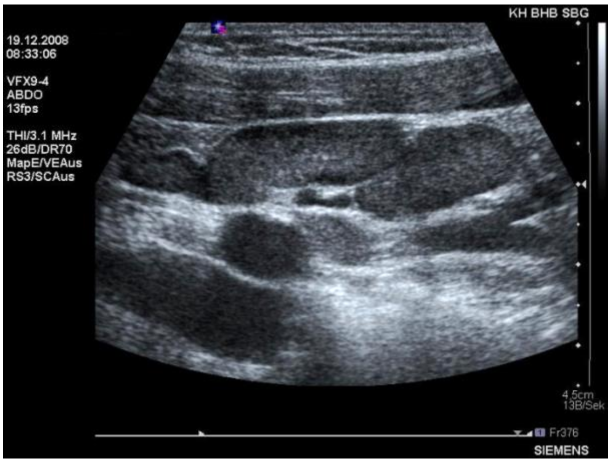
Figure 15 **Infectious colitis. This longitudinal view of the ascending colon shows the so-called accordion sign, which is a consequence of wall thickening and contraction. A hyperechoic swelling of the submucosa is especially prevalent.**

Figure 16 **Infectious ileocaecitis. Both the terminal Ileum (arrow) and the caecum (arrowheads) are thickened on this transverse scan in the right lower quadrant (a). The mesenteric lymph nodes are moderately enlarged and tender on graded compression (b).**

a



b



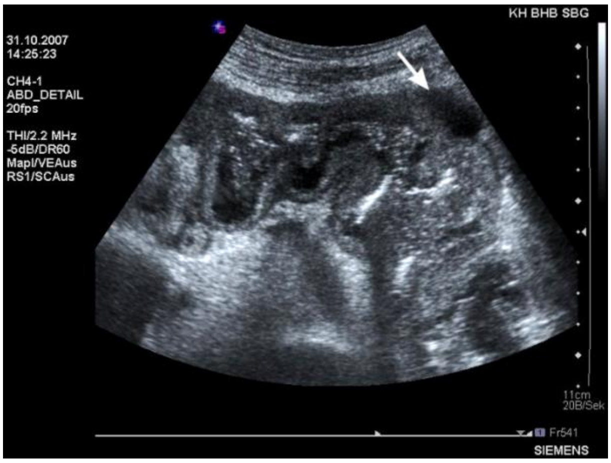
Pseudomembranous colitis

Pseudomembranous colitis usually occurs as a complication of antibiotic therapy with overgrowing Clostridium difficile bacteria. Severe pseudomembranous colitis is a potentially life-threatening condition and early diagnosis is essential in safeguarding the patient from this stage of disease.

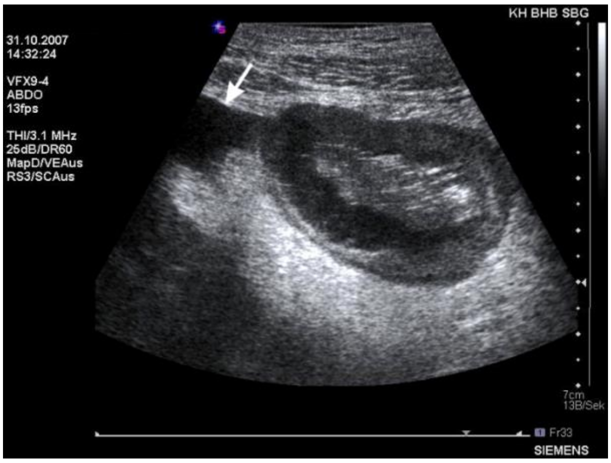
Pseudomembranous colitis frequently manifests as pancolitis, but may also be segmental [41, 42]. Wall thickness increases with severity of disease and stratification becomes indistinct [Figure 17]. Alteration of the pericolic fat and ascites are further signs in severe cases. Medical treatment should be started immediately in cases of marked pancolitis after antibiotic therapy and a positive quick test for Clostridium difficile.

Figure 17 Pseudomembranous colitis. A longitudinal scan of the sigmoid colon (a) and a transverse scan (b) with a high-frequency transducer show marked wall thickening with partly indistinct stratification. Hyperechoic alteration of the pericolic fat and ascites (arrow) are also visible.

a



b



Neutropenic enterocolitis

Neutropenic enterocolitis is a complication following chemotherapy or transplantation and in patients with other immunosuppressive conditions. It is characterised by ileal and, to a variable extent, right-sided colonic involvement [43]. Bowel loops are thickened and stratification may be preserved or be partly destroyed. In addition, alteration of the adjacent mesenteric fat and ascites may be present [Figure 18]. In the clinical context a correct diagnosis can frequently be established by ultrasound.

Figure 18 **Neutropenic enterocolitis. This sonogram shows thickened ileal loops in a patient after chemotherapy. The partly destroyed stratification (hypoechoic**

changes of the submucosa) and the hyperechoic alteration of the mesenteric fat are signs of transmural inflammation.

Inflammatory bowel disease

Both Crohn's disease and ulcerative colitis typically occur in young adults but can also affect children or elderly patients. At times, clinical symptoms, such as cramping abdominal pain, diarrhoea and rectal bleeding precede a definite diagnosis for months. Ultrasound signs of chronic inflammatory bowel disease, especially in Crohn's disease, contribute to earlier endoscopic and histological proof [44]. B-mode ultrasound, colour Doppler imaging, and more recently CEUS, can provide additional information on disease activity and treatment success [45].

Crohn's disease

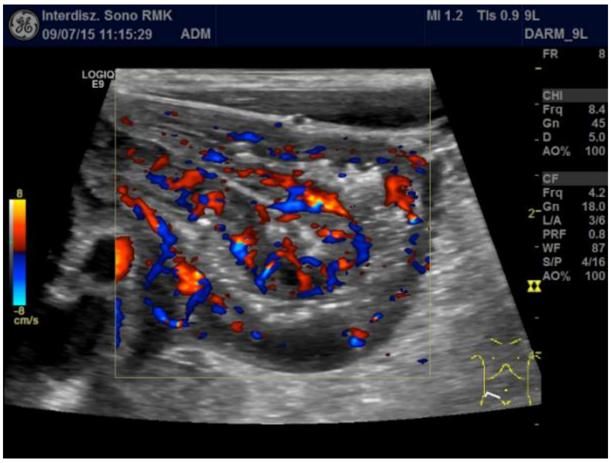
Crohn's disease predominantly involves the distal ileum and the colon. The affected bowel segment appears markedly thickened and the lumen is narrowed resulting in the classic sonographic "target sign" on transverse images. In contrast to ulcerative colitis, involvement is discontinuous with intervals of normal bowel producing "skip areas". Transmural inflammation through all layers of the intestinal wall is another typical sign of the disease and can lead to complete loss of stratification [46-50]. The mesentery and other adjacent structures are frequently involved in the inflammatory process. The affected bowel is then surrounded by non-compressible fatty tissue, which is sometimes traversed by finger-like hypoechoic bands. Evidence of hypertrophic fat around the bowel is called the “creeping fat sign”. Enlargement of mesenteric lymph nodes is frequently present, usually in the right lower quadrant [Figure 19].

Figure 19 **Crohn’s disease. A cross-section in the right lower quadrant shows the thickened terminal ileum. Stratification is partly preserved and partly destroyed (a). The inflamed bowel loop is surrounded by hyperechoic mesenteric fat. Severe inflammation of the mesentery is visible as a hypoechoic irregular mass next to a thickened ileal loop (b). On colour Doppler ultrasound (not shown) hypervascularisation was visible in the hypoechoic areas. Hypervascularisation of the terminal ileum in a patient with Crohn's disease (c).**

a

b

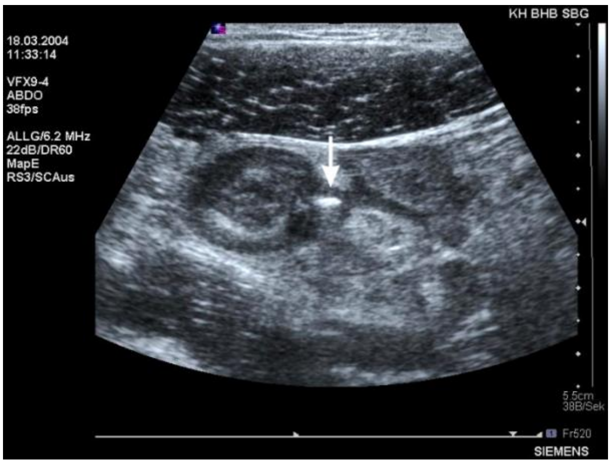
c



Possible complications of Crohn’s disease include fistulas, abscess formation, bowel obstruction, stenosis and rarely perforation [Figure 20]. Fistulas are visible as hypoechoic tracts with hyperechoic gas inclusions. Abscesses are seen as poorly defined, mostly hypoechoic focal masses that can contain hyperechoic gas.

Figure 20 **Crohn’s disease. Gas bubbles in the bowel wall and the adjacent mesentery are indicative of a small fistulous tract (a, arrow). Panoramic view of the ileum shows dominantly fibrotic stenosis with moderate dilatation of non-involved proximal ileal loops (b).**

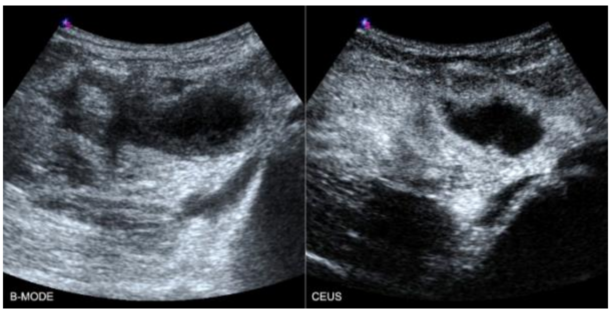
a



b

Wall thickness, change of wall stratification, the length of the involved segment and complications are parameters to describe disease activity on B-mode ultrasound. There are many published studies concerning pulsed Doppler and colour Doppler imaging of the bowel wall for estimating disease activity [51-53]. Colour Doppler has also been used to facilitate differentiation of inflammatory from fibrotic stenosis in patients with obstructive Crohn's disease. However, results remain somewhat controversial because histological examination of resected specimens in many cases shows coincidence of both inflammation and fibrosis. Hoping for quantification of bowel wall vascularisation by means of CEUS, different software applications using parameters like time to peak (TTP), area under the curve (AUC) or blood flow volume have been described in literature. But they could not yet gain acceptance in daily practice. In difficult cases CEUS can be a very useful tool for better delineation of abscess formations or fistulous tracts [Figure 21] [54].

Figure 21 Crohns's disease. This contrast study clearly delineates the avascular mesenteric abscess formation from surrounding hypoechoic inflammatory alterations of the mesentery on B-mode ultrasound.



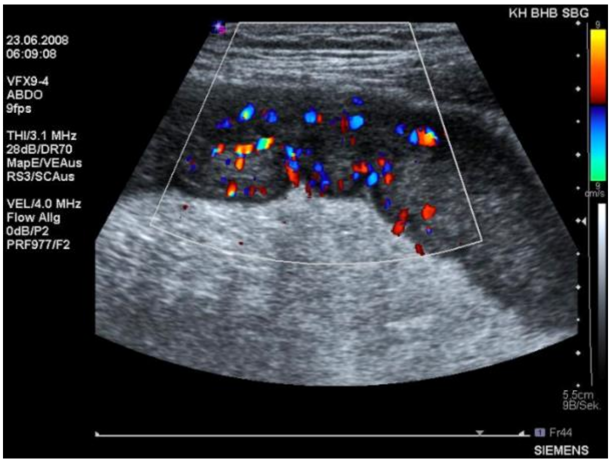
Ulcerative colitis

Colon involvement in ulcerative colitis is continuous from the rectum and extends more or less to the upper colon. Bowel wall thickening is usually less marked and stratification is preserved because inflammation is predominantly located in the mucosa. In cases of acute inflammation the submucosa is thickened mainly owing to oedema, and tends to become more hypoechoic with the severity of disease [Figure 22]. The muscular layer and the pericolic fat are usually not involved [55]. After resolution of the acute inflammation, the colon wall returns to its normal appearance or remains, after several recurrences, slightly thickened with a hyperechoic submucosa. Toxic megacolon is a potentially lethal complication of ulcerative colitis in which the colon is distended and signs of toxicity are present.

Figure 22 **Ulcerative colitis. Panoramic view of the sigmoid colon shows moderate thickening of the colon with preserved bowel-wall layers in a case of sub-acute ulcerative colitis (a). An acute episode of ulcerative colitis led to this marked hypoechoic thickening of the colonic wall. Stratification is indistinct and hypervascularisation is present (b).**

a

b



Coeliac disease

Coeliac disease is a chronic disease with mucosal damage and impaired nutrient absorption as a consequence of inflammatory reaction to gliadin, a gluten protein found in wheat.

The classic clinical presentation includes diarrhoea, steatorrhoea, flatulence, weight loss and fatigue. Many patients present with non-specific symptoms and ultrasound can, therefore, play a useful role in shortening the diagnostic process.

A combination of the following non-specific ultrasound signs increases the suspicion of coeliac disease [Figure 23] [56-58].

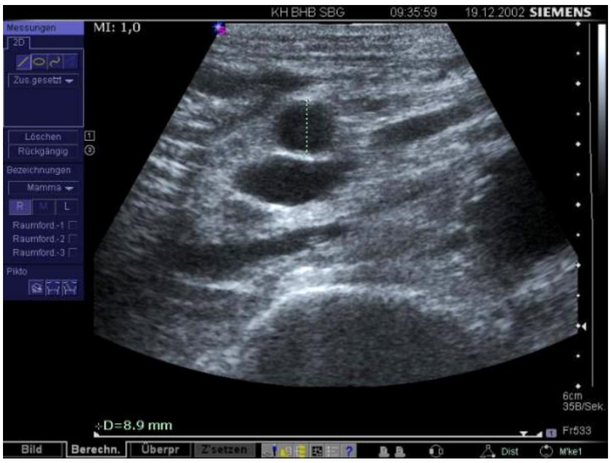
- abnormal fluid-filled small intestine with hyperperistalsis;
- transient intussusception as a consequence of hyperperistalsis is frequently seen;
- moderately dilated and flaccid small-bowel loops (diameter up to 3.5cm)
- slight thickening of the small-bowel wall and the valvulae conniventes;
- reduced number of jejunal folds and increase in number of ileal folds;
- enlarged mesenteric lymph nodes with preserved architecture;
- dilated calibre of superior mesenteric vessels;
- small amount of free fluid in the abdominal cavity;
- increased echogenicity of the liver despite low body mass index.

Diagnosis is confirmed by biopsy of the mucosa of the proximal small intestine, and clinical and histological improvement following implementation of a gluten-free diet. This diet becomes the treatment of choice for the rest of the patient's life.

Figure 23 **Coeliac disease. A sonogram in the lower abdomen shows fluid-filled moderately dilated, but flaccid small bowel loops (a). Peristalsis was markedly increased. Mesenteric vessels on a transverse scan of the upper abdomen are widened as a consequence of chronic hypervascularisation (b).**

a

b



Ischaemic disease

Early diagnosis of bowel ischaemia is essential in the management of patients with acute abdominal pain as ischaemic tolerance of the intestines is low. Acute mesenteric ischaemia is caused by arterial occlusion, venous occlusion, or non-occlusive disease. Patency of the main mesenteric vessels does not exclude ischaemic disease.

Ultrasound is often the first imaging method performed in patients with acute abdominal pain. However, early diagnosis of bowel ischaemia is difficult. Overlying gas often hinders the evaluation of the main mesenteric vessels, segmental and subsegmental arteries cannot be demonstrated completely, and sensitivity of colour Doppler to demonstrate microperfusion in the bowel wall is inadequate. Introduction of CEUS may contribute to overcome some of these problems. Angiography and, increasingly, multidetector CT are the imaging methods of choice if ultrasound is unable to reliably demonstrate the mesenteric vessels.

Bowel infarction

Acute mesenteric occlusion is often associated with multimorbidity and a high lethality. Segmental ischaemic disease has a better prognostic outcome because surgical treatment is possible even in the late phase.

Although angiography is considered the best method to diagnose mesenteric embolism or thrombosis, this method is invasive and not suitable for patients who are only suspected of having the disease. As a consequence, this method is often performed late. A delay in definite therapy results in high morbidity and mortality. Nowadays, multidetector CT angiography and advances in ultrasound contrast media contribute to an earlier diagnosis.

In cases of arterial occlusion, a short early and intermediate phase with non-specific hyperperistalsis in ultrasound examination is followed by the necrotic phase. A paralytic ileus with dilated fluid-filled loops develops and intramural gas collections or portal venous gas may be visible [Figure 24].

In cases of strangulation and venous thrombosis, the sonographic signs are more pronounced and more clearly visible [Figure 25a]. Bowel wall thickening and ascites are often the predominant signs.

The lack of colour Doppler signals in thickened bowel loops is highly suspect of bowel ischaemia [Figure 25b] [59]. Sensitivity to demonstrate microperfusion is inadequate, especially in the depth. Initial data for CEUS show promising data for assessing bowel ischaemia. However, its definite role remains unclear and for this method visible vascularisation does not exclude non-occlusive ischaemic disease.

Another interesting aspect is the vascularisation in the subacute phase (days to weeks) or chronic phase (months) of ischaemia. Similar to ischaemic colitis (see below) we can observe slight to moderate hypervascularisation in bowel segments with ischaemic damage but without necrosis.

Figure 24 **Small bowel infarction. Paralytic fluid-filled small-bowel loops show gas bubbles in the bowel wall as a consequence of mesenteric embolism with small bowel infarction and gangrene. Ascites is visible between the bowel loops.**

Figure 25 **Small bowel infarction. Significant hypoechoic thickening of a small bowel segment is visible in a patient with thrombosis of the mesenteric vein and haemorrhagic infarction owing to Factor V Leiden thrombophilia (a). An aperistaltic small bowel segment shows no vascularisation in the thickened wall owing to haemorrhagic infarction (b).**

a

b

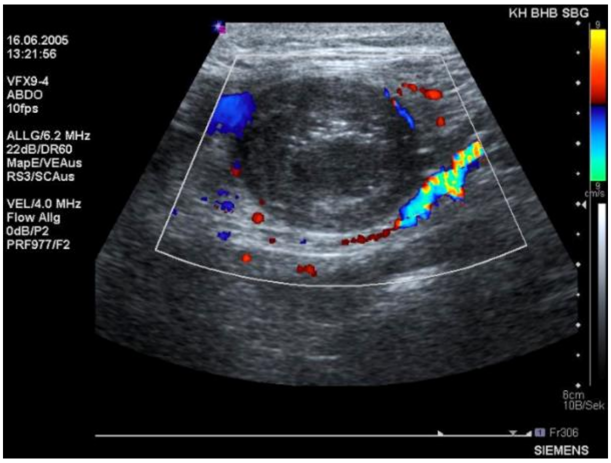
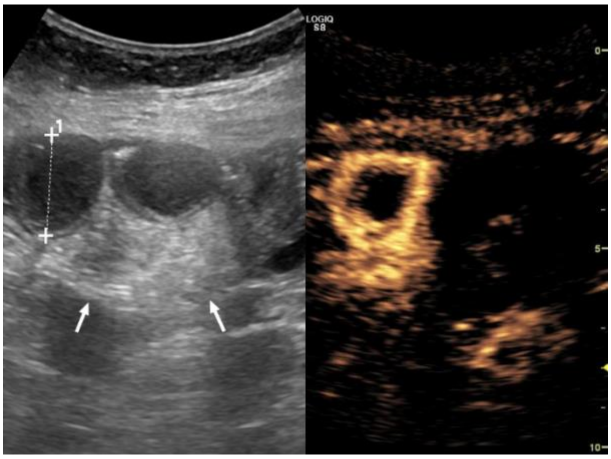


Figure 26 **Small bowel infarction. B-mode ultrasound showed aperistaltic small bowel loops with slight wall thickening and hyperechoic thickening of the mesentery (arrows). CEUS in the same region clearly demonstrated one loop with regular perfusion and adjacent loops without perfusion proving bowel infarction.**



Chronic ischaemia

Chronic mesenteric ischaemia can be differentiated from acute ischaemia. Sonographic results are better in this case because conditions for investigation are usually better. Main causes of chronic mesenteric ischaemia are stenoses of the main mesenteric vessels or occlusions with collateral circulation [Figure 27 and 28].

Circumscribed increases in flow velocity in colour Doppler ultrasound have to be proven with pulsed Doppler ultrasound. In healthy individuals peak systolic velocity ranges from 100-150 cm/s in the coeliac trunk and from 100-180 cm/s in the superior mesenteric artery. Systolic velocities of more than 250-300 cm/s are sensitive indicators of severe arterial stenosis. Peak velocities distal to the stenosis are reduced.

Doppler ultrasonography has been advocated as a reasonably accurate screening modality for the detection of high-grade superior mesenteric artery stenoses. Sensitivity exceeding 90% and a negative predictive value of close to 99% has been reported in patients with more than a 50% stenosis. On the other hand, sonographic detection of stenoses of mesenteric vessels may be of limited clinical relevance without knowledge of collateralisation. A positive study should be followed by angiography, which can further establish the feasibility of revascularisation.

Figure 27 **Superior mesenteric artery occlusion. The superior mesenteric artery is occluded a few centimetres from the origin. Colour flow in different directions is visible proximal and distal to the occlusion owing to retrograd inflow via collateral vessels.**

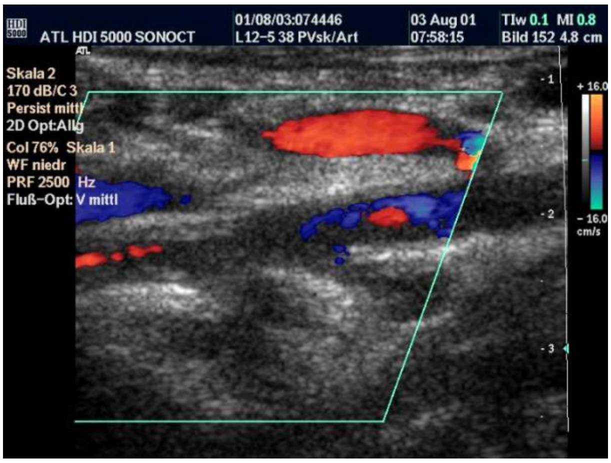
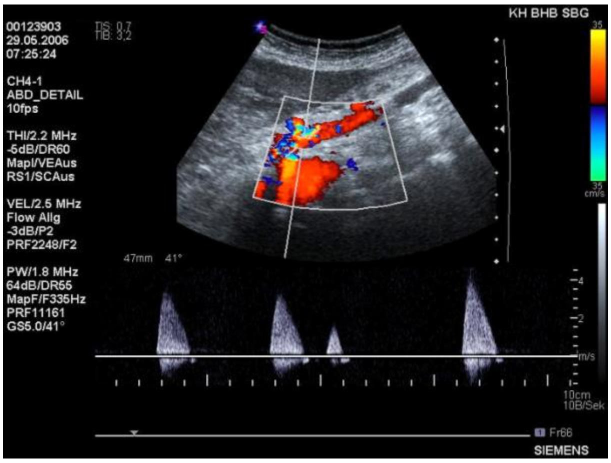


Figure 28 **Superior mesenteric artery stenosis. At the origin of the superior mesenteric artery pulsed Doppler shows systolic acceleration up to 4m/sec and turbulent flow indicative of a high-grade stenosis.**



Ischaemic colitis

Mild abdominal pain, diarrhoea, and mild rectal bleeding in elderly patients are clinical signs of ischaemic colitis. Most cases are transient forms that need medical treatment. Urgent surgical interventions owing to gangrene or perforation are quite rare.

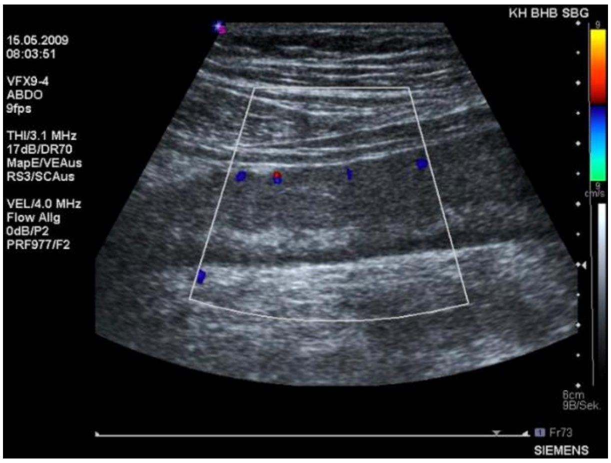
The left hemicolon from the splenic flexure to the sigmoid colon is the most frequent localisation of ischaemic colitis. A sudden transition from a normal colon to a hypoechoic thickened ischaemic segment is a typical ultrasound sign. In the acute stage of disease, the bowel wall layers are less distinctly differentiated and colour flow is barely visible [Figure 29]. In the subacute stage reparative changes may cause increased vascularity, which in turn is a good prognostic sign [60].

Ischaemic colitis of the right hemicolon or of the caecum alone is rare. However, ischaemic colitis should be suspected in elderly patients if the wall thickening is combined with reduced vascular flow [61].

Figure 29 Ischaemic colitis. A longitudinal sonogram of the descending colon shows moderate wall thickening with indistinct stratification (a). Only few vessels could be demonstrated using colour Doppler imaging (b).

a

b



Tumourous disease

Abdominal ultrasound is often the first imaging method that patients with GI tumours undergo when they present with non-specific symptoms. Careful sonographic evaluation of the GI tract may disclose focal masses. Tumours may be seen as polypoid lesions or as semicircumferential or circumferential wall thickening with wall layers frequently being destroyed. Local lymph node enlargement and focal liver lesions are signs of metastatic spread.

Gastric tumours

Gastric cancer produces a localised or diffuse hypoechoic wall thickening with destruction of the normal layered appearance. Ultrasound is not primarily used to diagnose gastric cancer, but may give additional information about local tumour infiltration. It may also be helpful in cases of scirrhous-type gastric cancer with significant thickening of the gastric wall on ultrasound examination if endoscopy with biopsy is negative [Figure 30].

Other causes of gastric wall thickening, such as severe gastritis, portal hypertension or pancreatitis must be differentiated from tumourous disease. Endoscopic examination with biopsy usually confirms the benign or malign genesis of the wall thickening.

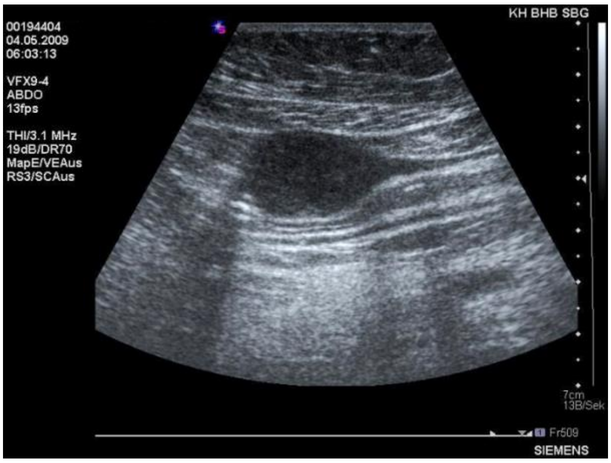
The stomach is the most common site of GI non-Hodgkin's lymphoma followed by the small intestine and the colon. Circumferential, profoundly hypoechoic and extensive wall thickening is indicative of a lymphoma. Pseudocystic lymph node enlargement is frequently present [62].

Gastrointestinal stromal tumours (GIST) are KIT(CD 117)-positive, mesenchymal tumours originating from the interstitial cells of Cajal, which are located in the muscular layer. 60% occur in the stomach and 30% in the small intestine [Figure 31]. In the case of small tumours, the bulging mucosal surface is regular, but for larger tumours, ulceration may be present and the cause of GI bleeding.

Figure 30 **Gastric cancer. Wall thickening of the gastric antrum is clearly visible. The muscular layer is discernible, but the mucosal and submucosal layer cannot be distinguished owing to tumour infiltration by a scirrhous carcinoma.**

Figure 31 **Gastrointestinal stromal tumour. A longitudinal sonogram of the gastric antrum shows a hypoechoic ovoid mass originating from the outer hypoechoic layer of the anterior wall (a). This circumscribed lesion originating from the gastric wall was more clearly demonstrated after ingestion of 500 mL of fluid (b). The wall layers are preserved and the mucosal and submucosal layers are clearly visible.**

a



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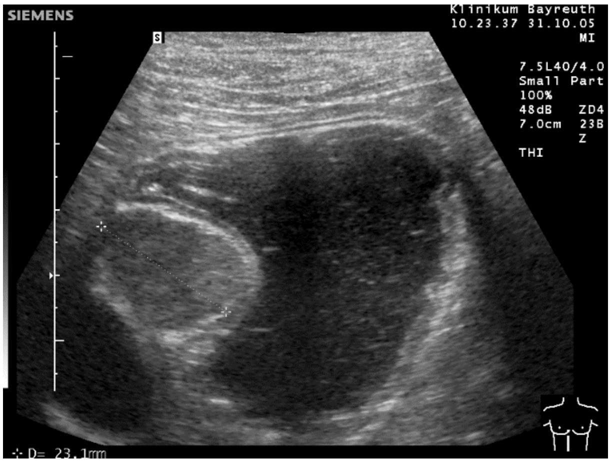


Tumours of the small bowel

Small bowel tumours are relatively rare. The most common tumours are neuroendocrine carcinomas (carcinoids), lymphomas, adenocarcinomas, GISTs and lipomas. Carcinoid tumours are small and mesenteric lymph node metastases or liver metastases are often detected earlier than the primary tumour [Figure 32]. GISTs are seen as focal hypoechoic masses protruding from the bowel wall and intussusception may occur as a consequence of such a mass [Figure 33]. Both tumours are hypervascularised on colour Doppler ultrasound. Lipomas are typically visible as hyperechoic, ovoid and smooth delineated lesions [Figure 34]. Hypoechoic "pseudocystic" appearance of bowel wall thickening and of enlarged lymph nodes is indicative of an intestinal lymphoma [Figure 35].

Figure 32 **Neuroendocrine carcinoma of the ileum. A polypoid tumour was detected in the ileum in an asymptomatic patient. The tumuor probably originates from the mucosa and is hypervascularised. Histologic examination revealed a neuroendocrine carcinoma with small lymph node metastases.**

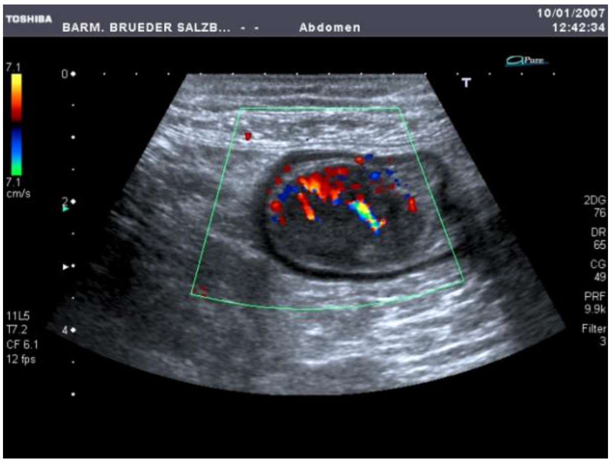
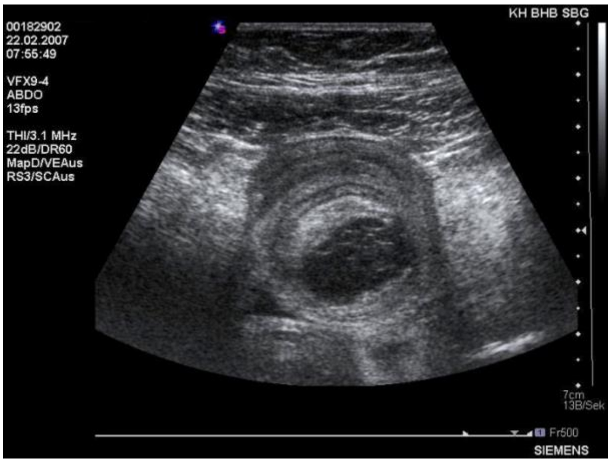


Figure 33 **Gastrointestinal stromal tumour and intussusception. A patient with episodes of cramping abdominal pain and iron deficiency anaemia showed a target lesion in the mid-abdomen indicative of intussusception (a). The central hypoechoic mass acted as the leading point. Colour Doppler ultrasound revealed hypervascularisation of the tumour (b).**

a



b

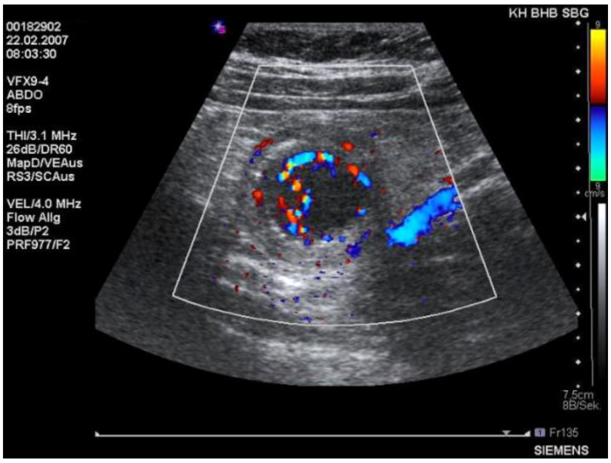


Figure 34 **Jejunal lipoma. A homogenous hyperechoic mass fills the lumen of a jejunal loop. Episodes of abdominal pain were caused by recurrent intussusception (not shown). Markers show diameters of the lipoma.**

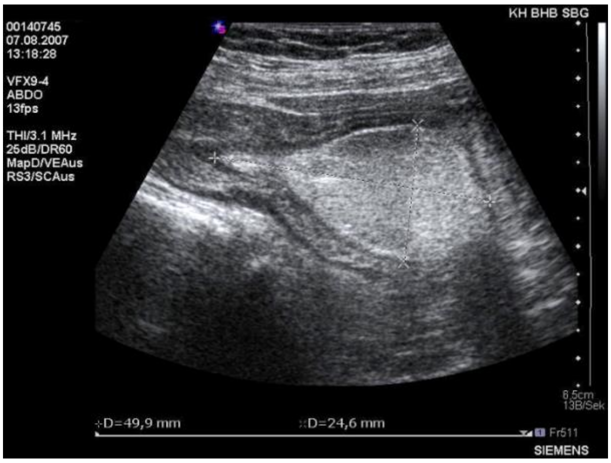
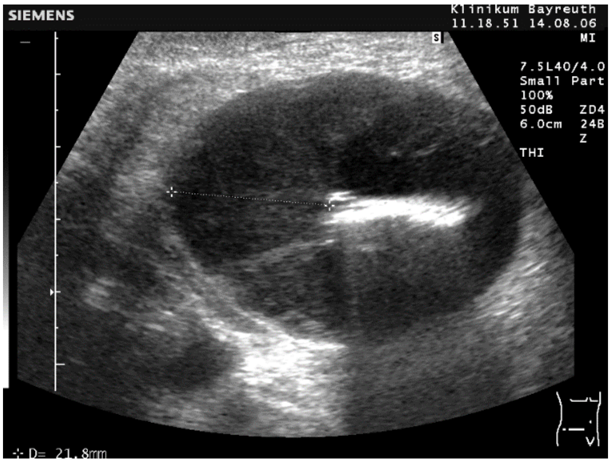


Figure 35 **Ileal non-Hodgkin's lymphoma. Marked hypoechoic wall thickening of an ileal loop is present in a patient with high-grade non-Hodgkin's lymphoma. Wall layers are no longer discernible. Markers show diameter of the thickened hypoechoic ileal wall.**



Tumours of the colon

Colorectal cancer is the second most common tumour in the Western world. Colonoscopy, and to a lesser extent also CT-colonography, are the screening methods for these carcinomas, which usually evolve from adenomatous polyps over several years.

In experienced hands, ultrasound can demonstrate a high percentage of T3 and T4 tumours and approximately one-third of T1 and T2 tumours. It is only possible to demonstrate polyps in a minority of cases [62]. Colour Doppler ultrasound can help to differentiate polyps from hypoechoic faecal material [Figure 36]. Carcinomas usually present as hypoechoic short segmental and asymmetric wall thickenings. The hypoechoic wall thickening with the central hyperechoic luminal content is also called the pseudokidney sign [63-67]. Bowel wall layers are increasingly destroyed with tumour progression [Figure 37]. Loss of outer smooth delineation of the colonic wall is indicative of tumourous infiltration to the pericolic fat and adjacent organs [Figure 38]. Patients with colonic cancer are also evaluated for local lymph node enlargement and focal liver lesions as a sign of metastatic spread.

Other tumours of the colon include lymphomas [Figure 39], GISTs, and lipomas. Lipomas and GISTs arise from the submucosa and the muscularis propria. Lipomas are hyperechoic in contrast to GISTs and lymphomas. GISTs and lymphomas are usually hypervascularised on colour Doppler ultrasound.

Figure 36 **Colonic polyp. Power Doppler ultrasound clearly shows vascularisation in the ovoid hypoechoic lesion in the transverse colon.**

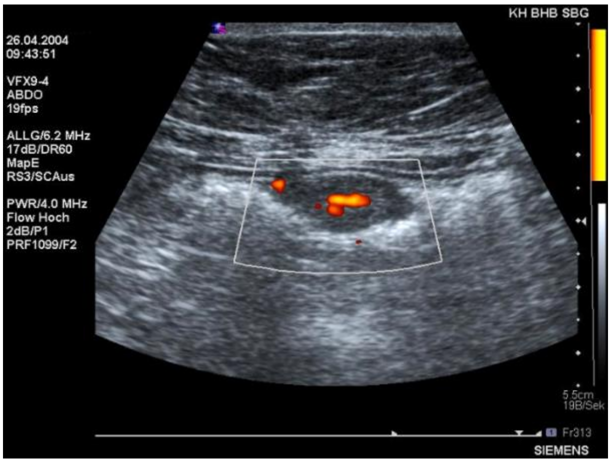


Figure 37 **Sigmoid carcinoma. Longitudinal section of the sigmoid colon shows circumscribed wall thickening with destruction of wall layers (a). Hypervascularisation and irregular vessels are also typical of colon carcinomas (b).**

a

b

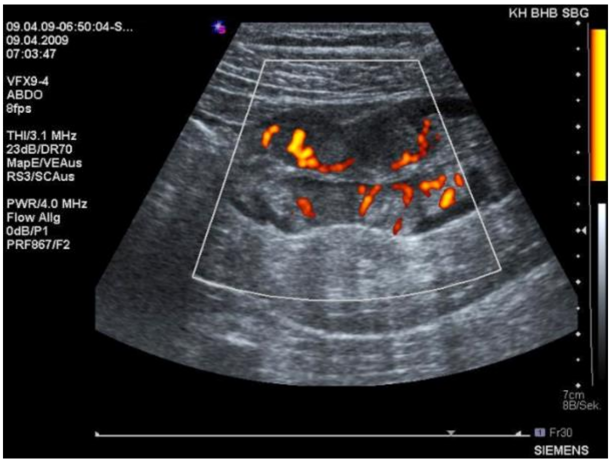


Figure 38 **T3-carcinoma of the transverse colon. An ultrasound scan shows the asymmetric wall thickening with infiltration of the pericolic fat (arrows).**

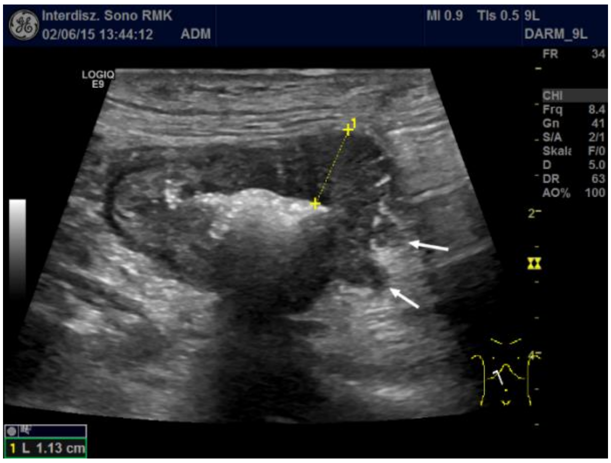
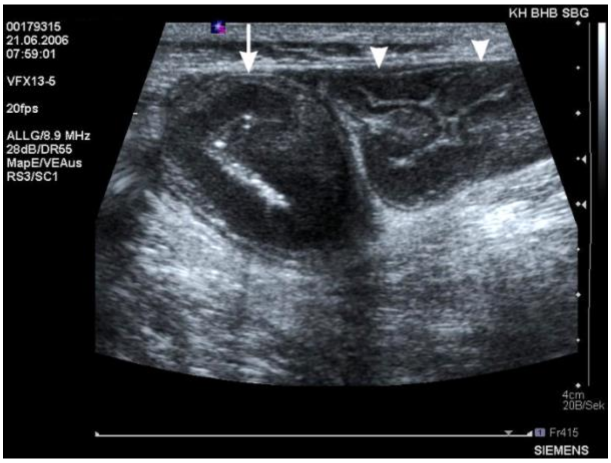


Figure 39 **Non-Hodgkin lymphoma. Hypoechoic thickening predominantly of the mucosal layer is present both in the caecum (arrow) and in the terminal ileum (arrowheads).**



Paediatric diseases

There are some diseases which typically occur in newborns and in childhood; because clinical evaluation of these patients is sometimes difficult, accurate sonographic diagnosis is essential.

Congenital malformations

Congenital malformations include duplication cysts, malrotation of the gut and obstruction by duodenal or anal atresia. Some malformations show typical ultrasound appearance, others need further evaluation. Huge dilatation of the proximal duodenum and the stomach in duodenal atresia and direct visualisation of the meconium-filled rectum in anal atresia are typical sonographic signs. In anal atresia perineal ultrasound and three-dimensional ultrasound can help the more accurate measurement of the length of the atretic canal and therefore adequate therapeutic management [68].

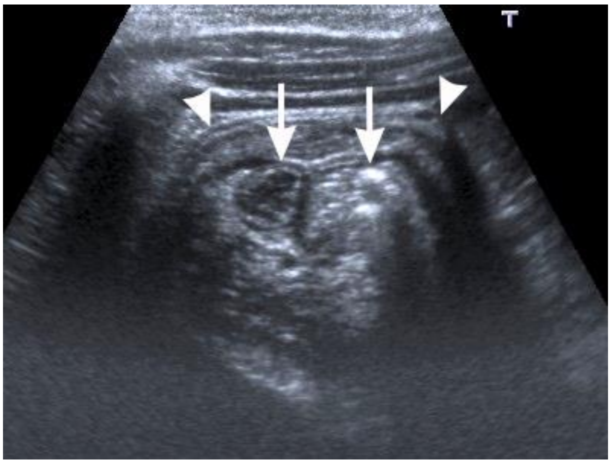
Intussusception

Intussusception is the most common acute abdominal disorder of early childhood. Usually ileocolic type intussusception is present. Ultrasound is now the imaging method of choice for this diagnosis with a sensitivity of approximately 100%.
The sonographic appearance of intussusception has been described as a “doughnut”, “target” or “onion” sign with multiple concentric rings surrounding an echogenic centre, which

corresponds to the mesenteric fat [Figure 40]. Ultrasound can also be used to monitor hydrostatic reduction [69, 70].

A substantial amount of fluid in the intussusception represents trapped peritoneal fluid and is associated with irreducibility and ischaemia. The lack of perfusion in the intussusceptum on colour Doppler ultrasound is also indicative of ischaemia. In this situation surgery should be performed.

Figure 40 **Intussusception. In this case of ileocolic intussusception, the outer concentric rings represent the colonic wall (arrowheads). The central intussusceptum consists of ileal loops (arrows) and the hyperechoic mesentery (kindly provided by H. Nemec).**



Hypertrophic pyloric stenosis

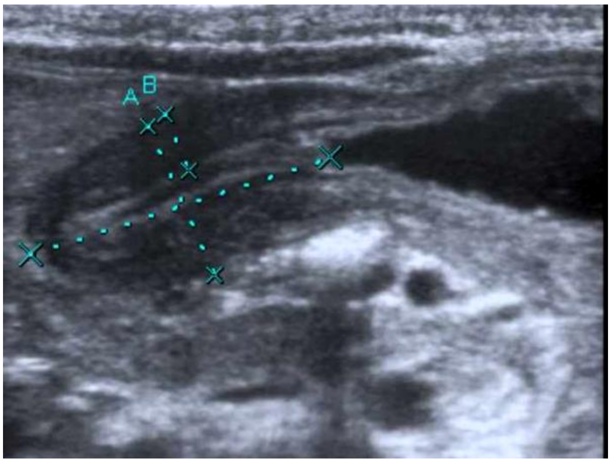
Hypertrophic pyloric stenosis clinically presents as vomiting in the third to fourth week of life and is associated with good appetite. Gastric peristalsis may be visible and a pyloric tumour is palpable.

The typical sonographic signs are a muscle thickness of at least 4mm and a channel length of at least 16mm [Figure 41]. Ultrasound may also be helpful in deciding between surgical or conservative treatment.

Figure 41 **Hypertrophic pyloric stenosis. (a) Ultrasound clearly shows hypertrophic pyloric stenosis as cause of gastric dilatation. (b) Measurement of the channel length and of muscular thickness performed in another child (kindly provided by H. Nemec).**

a

b



Necrotizing enterocolitis

Necrotizing enterocolitis (NEC) is one of the most common life-threatening GI diseases in newborns affecting 1-5% in the neonatal intensive care unit. Early detection of severely ischaemic or necrotic bowel loops before perforation can improve the high morbidity and mortality in NEC.

The major advantages of ultrasound over plain radiography are that it can depict intra-abdominal fluid, bowel wall thickness and bowel wall perfusion. The lack of perfusion in ultrasound is highly suggestive of necrotic bowel and may be seen prior to visualisation of portal venous gas or free intraperitoneal gas [71].

Other paediatric diseases

Other paediatric diseases with bowel wall thickening in ultrasound include vasculitis, inflammation and ischaemia. The most common site of GI involvement in patients with **Henoch-Schönlein purpura** is the distal portion of the small bowel. Colour Doppler flow is increased in these patients in the same way as in patients with **inflammation** of the bowel wall (enterocolitis; Crohn's disease, etc.). Both bowel wall stratification and non-stratification may be visible in vascular and inflammatory causes of bowel wall thickening. **Ischaemic colitis** secondary to haemolytic-uraemic syndrome often presents with wall thickening of more than 10 mm and absence of colour Doppler signals [72].

Ultrasound has proven to be a reliable tool for evaluation of gastro-oesophageal reflux in the first year of life. Using standardised protocols and diet, conventional ultrasound and colour Doppler ultrasound can depict and document episodes of reflux. Nowadays second-generation contrast agents are also used in this situation.

Sonographic findings are helpful in examining patients with signs of malabsorption. In addition to the abnormal appearance of the small bowel with increased fluid and hyperperistalsis, some patients with **coeliac disease** show slight ascites, pericardial fluid or liver tissue texture changes [58].

Conclusion

Ultrasound is a first stage imaging method for patients with acute abdominal symptoms and provides correct diagnosis in a high percentage of patients. Ultrasound is also a valuable tool for monitoring acute and chronic intestinal diseases. It gives additional information to endoscopic and radiological examinations especially concerning the transmural aspect of disease. When determining the part of the GI tract involved, ultrasound can contribute to well-directed further evaluation.

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