Transabdominal ultrasound in the initial assessment of adult bowel diseases

Introduction

Transabdominal ultrasound is increasingly chosen as the initial imaging technique in the radiological work-up of bowel abnormalities in adults because ultrasound can provide substantial information about gastrointestinal disorders. In the presence of pathological changes in the intestine, sonographic findings, such as thickening of the bowel wall, changes in the perienteric fat and vascularity, have recognizable and reproducible appearances (Kuzmich et al, 2009). Although the diagnostic quality of ultrasound can be compromised by bowel gas and obesity, ultrasound has a number of strengths, including its ability to allow real-time correlation between the sonographic findings and the area of maximum tenderness combined with excellent spatial resolution, wide availability, lack of radiation and its non-invasive nature.

This article illustrates the key sonographic features of commonly encountered bowel disorders in adults and highlights ultrasound techniques that may assist in diagnosis.

Technique

Ultrasound examination of the intestine is performed after a standard examination of the solid abdominal organs. In patients with localized abdominal pain, the examination should start at the point of maximum tenderness.

The choice of transducer largely depends on the achievable distance between the transducer and the area of interest. While 2.5–5 MHz curvilinear probes may be the only choice for assessment of deep-lying structures and in obese patients, 7–12 MHz linear transducers facilitating high-resolution imaging are used to assess areas that are accessible. Graded compression is used to decrease the distance between the probe and the area of interest by displacing gas and faecal residue.

The general intestinal study is started in the right abdomen by identifying the ascending colon which is recognized by its lack of peristalsis, fixed position and haustra. The ascending colon is followed in the transverse plane to the right lower quadrant, where the caecum is found. The terminal ileum is identified as a loop of small bowel joining the caecum. The appendix is visualized as a small (usually <6 mm in diameter), easily compressible, mobile, blind-ending, aperistaltic tubular structure (*Figure 1*) arising from the posteromedial caecum. The colonic wall is subsequently followed from the caecum along the ascending, transverse and descending colon through to the distal sigmoid colon into the pelvis.

Small bowel is identified by the presence of peristalsis and/or circular folds when the lumen is fluid filled. The loops of small bowel are scanned in a general sweep from the epigastrium across the mid abdomen down to the pelvis.

A suspicious area is given detailed analysis. Colour and power Doppler are used to assess the perfusion of thickened intestinal wall or a suspected solid mass. The mesentery and perienteric fatty tissue are assessed for infiltration, presence of fluid and lymph nodes.

Sonographically normal bowel wall consists of five concentric layers (*Figure 1*). The average mural thickness of normal large intestine is less than 4 mm, and the upper limit of normal small intestinal wall is 2 mm.

Inflammatory conditions

Appendicitis

Ultrasound is the modality of choice for confirmation or exclusion of clinically suspected appendicitis; sensitivity and specificities of over 95% can be achieved (Kessler et al, 2004). The ultrasound criteria for the confident diagnosis of acute appendicitis (*Figure 2a*) include:

- Inflammatory change in the mesoappendix or periappendiceal fat
- Guarding over the enlarged appendix triggered by selective probe compression

Figure 1. Transverse scan of right iliac fossa showing a normal appendix (A) and ileum (I). On high resolution ultrasound bowel wall consists of five concentric layers arranged in a pattern, inner to outer: a thin reflective layer of superficial mucosal interface – hypoechoic deep mucosa – hyperechoic layer of submucosa – hypoechoic muscularis – reflective interface of the serosa. Gross identification of reflective inner mucosa, hypoechoic muscular layer, and reflective stripe of serosa is usually sufficient in clinical practice.

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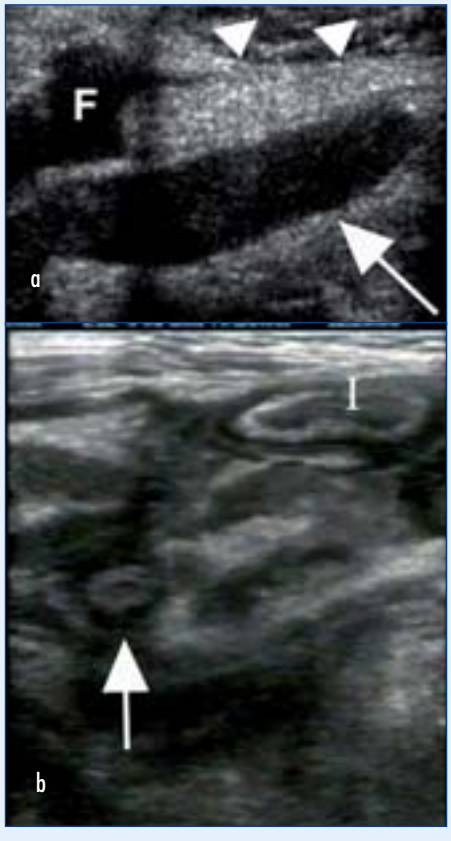
- Demonstration of distended appendix >6 mm associated with its loss of compressibility and mobility
- Presence of an appendicolith, even in an otherwise normal-appearing appendix.

The presence of inflammatory changes in the right iliac fossa (*Figure 2b*) – hyperechoic non-compressible fat associated with fluid, lymphadenopathy, mild reactive thickening of terminal ileum and caecum or adynamic ileus – are important secondary features that should raise the suspicion of underlying appendicitis when the appendix cannot be confidently visualized or is normal in calibre having, in fact, perforated. However, the decision to operate should only be made after clinical correlation.

If the appendix cannot be identified, the absence of the secondary features of inflammatory change makes appendicitis unlikely.

Figure 2. a. Acute non-perforated appendicitis: 10 mm non-compressible appendix (arrow) in the right iliac fossa surrounded by hyperechoic inflamed periappendiceal fat (arrowheads) and free fluid (F). b. Perforated appendicitis. Note the appendix (arrow) is normal in calibre, but there is inflammatory change in the right iliac fossa with mild secondary thickening of the ileum (I).



The size of the appendix alone is not a reliable feature of appendicitis (Jeffrey et al, 1994). An enlarged appendix can be seen in ileocaecal Crohn's disease as a result of secondary involvement (*Figure 3*), caecal lymphoma and caecal carcinoma obstructing the appendiceal origin.

Ultrasound is of particular value in diagnosing atypically located appendicitis, e.g. deep pelvic, retrocaecal or subhepatic (*Figure 4*) when appendicitis is not suspected clinically. Another important benefit of ultrasound is its ability to rapidly demonstrate alternative pathologies which reduces the false-positive appendicectomy rate.

Sequelae may include appendiceal abscess which typically appears as a localized complex fluid collection. Enlarged appendix or mucocele can be found in patients presenting with symptoms of recurrent appendicitis.

Figure 3. Enlargement of the appendix secondary to ileocaecal Crohn's disease. Note thick-walled appendix (arrow) is not distended with fluid, and is in close proximity to the affected ileal loop (I).

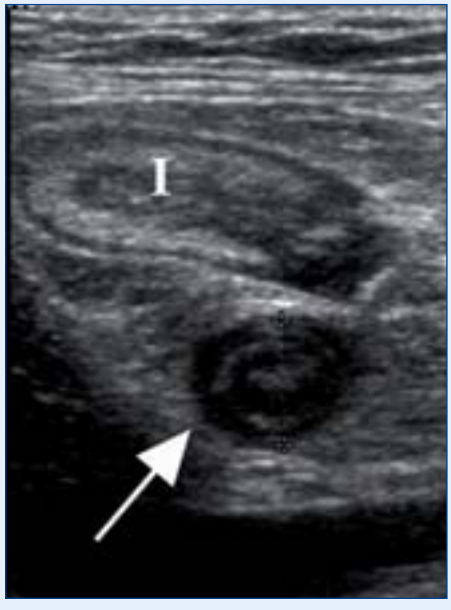


Figure 4. Atypically located subhepatic appendicitis. Longitudinal sonogram of the right upper quadrant depicts an enlarged appendix (arrow) extending under the liver margin (liver).

Ileocaecal infection

This usually self-limiting condition, associated with Yersinia, Campylobacter or Salmonella infection confined to the terminal ileum and caecum, can mimic appendicitis resulting in unnecessary appendicectomy. Characteristic sonographic features include marked hyperechoic thickening of the mucosa and submucosa of the terminal ileum and caecum associated with enlarged mesenteric lymph nodes and sonographically normal appendix. Importantly, the perienteric fat or mesentery is never involved which is a main discriminating point from Crohn's disease.

Colitis

Ultrasound has a role in suggesting an early diagnosis of colitis by demonstrating diffuse colonic wall thickening (*Figure 5*), the site of colonic involvement and inflammatory changes in the colonic wall. Ischaemic

Figure 5. Infectious colitis: diffuse hyperechoic thickening of ascending colon mucosa (arrow).

colitis may be suggested when poor or absent vascularity in the thickened colonic wall is confidently depicted on Doppler.

Crohn's disease

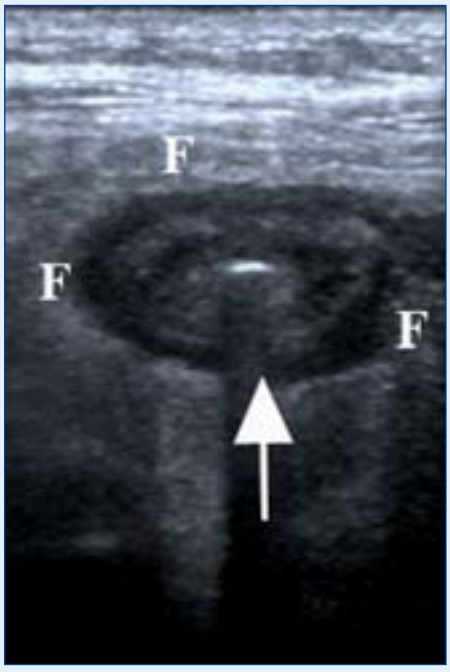
Ultrasound can suggest the initial diagnosis with a reported sensitivity and specificity of 89.7% and 95.6% respectively (Horsthuis et al, 2008). Further computed tomography and barium studies are usually warranted.

The affected segment (*Figure 6*) is typically aperistaltic, rigid, non-compressible and is seen to be wrapped in a hyperechoic layer of fat. This constellation of findings reflecting transmural involvement is diagnostic. The individual wall layers may not be discernible depending on the level of inflammation. Length, thickness and degree of hyperaemia of the affected bowel loop may reflect the disease activity. Ultrasound is the method of choice for serial follow up. Complications of Crohn's disease that can be detected at sonography include fistulas, abscesses and mechanical bowel obstruction.

Diverticulitis

Ultrasound is a valid primary technique for imaging of acute colonic diverticulitis, yielding similar results to computed tomography. The reported sensitivity ranges between 84% and 91% (Ripollés et al, 2003).

Figure 6. Crohn's disease: transverse section of a thickened ileal loop (arrow) wrapped with a hyperechoic layer of fat (F).



Ultrasound criteria for the diagnosis include demonstration of a swollen diverticulum protruding from the intestinal wall, hypoechoic thickening of the colonic segment where the diverticulum originates, inflammatory changes in the surrounding pericolonic fat (*Figure 7*), and tenderness of the area on selective compression with the probe.

Although ultrasound can reliably detect common complications of diverticulitis such as abscess formation, perforation and bowel obstruction, computed tomography remains the technique of choice for further evaluation.

Intestinal tract neoplasms

Benign tumours

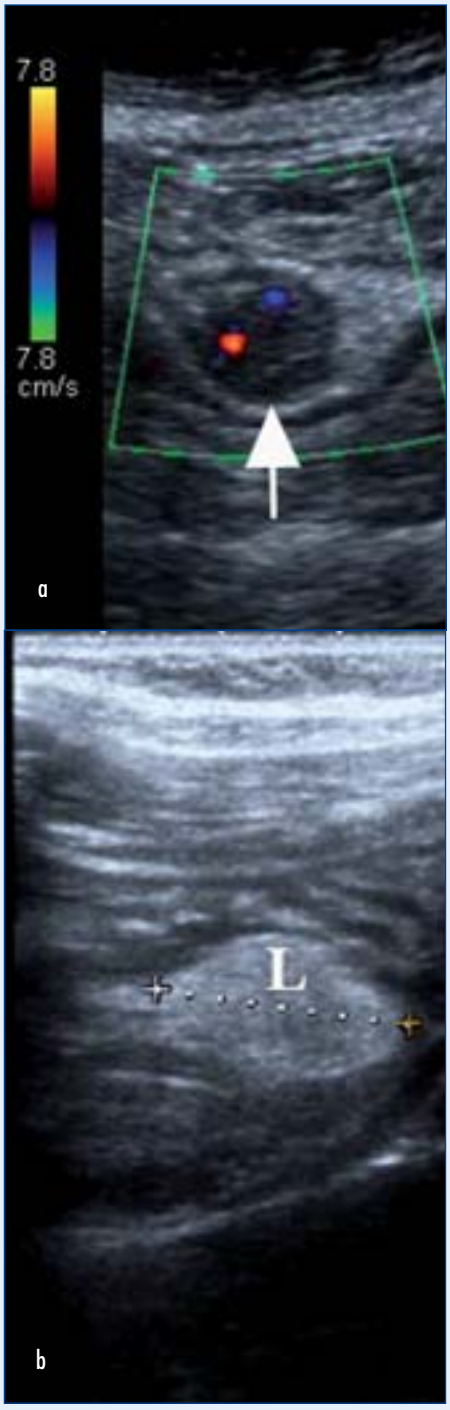
Detection of colonic polyps at ultrasound is usually incidental, although a sensitivity of 28.6% and specificity of 99.4% in the detection of polyps larger than 10 mm in diameter has been achieved (Koichi et al, 2006). Sonographic depiction of a solid hypoechoic lesion, within the intestinal lumen, which is vascular on Doppler is suspicious of a colonic polyp (*Figure 8a*). Bowel lipoma is typically visualized as a reflective homogeneous submucosal mass projecting into the intestinal lumen (*Figure 8b*).

Figure 7. Diverticulitis: longitudinal view of the sigmoid colon depicting a swollen diverticulum (arrow), thickened colon (C), and inflammatory change in the surrounding pericolonic fat (F).

Malignant tumours

Ultrasound is not the modality of choice but can suggest the initial diagnosis, usually during a routine scan. Small bowel tumours comprise carcinomas, carcinoids, lymphomas and sarcomas, and are rare.

Figure 8. Benign polypoid lesions. a. Transverse colour Doppler sonogram of proximal sigmoid colon depicts a small 16 mm vascular intraluminal lesion (arrow) – colonic polyp. b. Small bowel lipoma (L) depicted as reflective submucosal intraluminal lesion.



Lymphoma appears as a single or multiple short segments of hypoechoic circumferential bowel thickening with preservation of the submucosa.

Gastrointestinal stromal tumour accounts for 1–3% of all gastrointestinal tumours. The most common site of involvement is the stomach. Gastrointestinal stromal tumours do not involve the bowel wall concentrically, unlike adenocarcinomas, and at presentation the tumours are frequently large and asymptomatic. Ultrasound features typically include a well-defined heterogeneous exophytic smooth-muscle mass of intestinal origin with central cystic areas related to haemorrhage or necrosis (*Figure 9*).

Colon carcinoma

Carcinoma classically presents as a concentric, short segment of bowel wall thickening or as an irregularly shaped, lobulated, solid mass involving the colonic wall (*Figures 10a* and *b*). The diseased lumen is severely narrowed and is recognized because of the intraluminal gas. Abrupt loss of layer stratification is strongly suggestive of malignancy.

Figure 9. Gastrointestinal stromal tumour seen as a large heterogeneous mass (arrow) with central cystic areas (H) related to haemorrhage or necrosis.

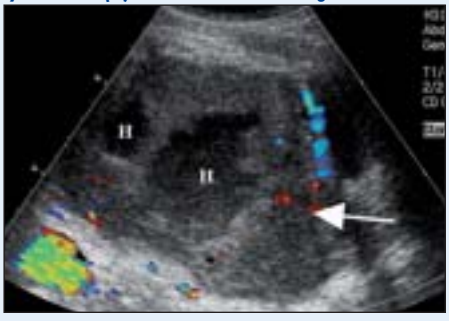
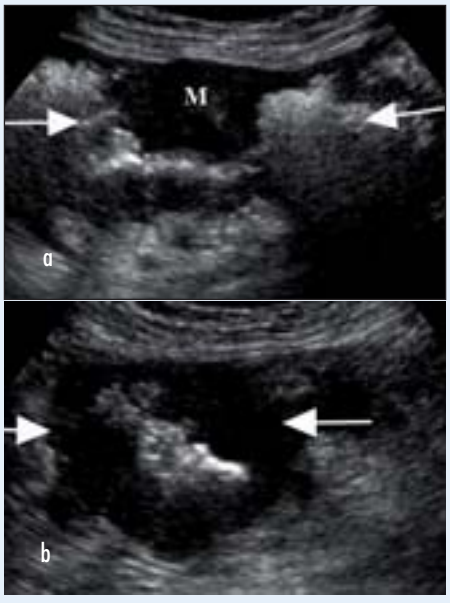


Figure 10. Colon carcinoma: (a) long axis and (b) transverse section of ascending colon depicting a short segment (arrows) of lobulated colonic wall thickening (M).



Intussusception

Intussusception characteristically appears as a target or doughnut sign (*Figure 11*) at ultrasound. Transient small bowel intussusceptions without a lead point involving short segments of intestine can be observed in adults and usually have no sequelae. Established intussusceptions involving long bowel segments should be inspected for the lead mass which, in adults, is typically a tumour, usually malignant in the colon and benign in small bowel.

Bowel obstruction

Ultrasound can suggest an early diagnosis hours before X-ray diagnosis is possible. Dilated to varying degrees, fluid-filled bowel loops (*Figure 12*) are readily detectable on real-time ultrasound. The cause of obstruction, such as band adhesions, caecal volvulus, incarcerated hernia, neoplasm, Crohn's disease or intussusception, can also be identified.

Figure 11. Intussusception depicted as a target or doughnut sign.

Figure 12. Small bowel obstruction. A dilated fluid-filled small bowel loop is readily detectable on real-time ultrasound shortly after clinical presentation.

Conclusions

Transabdominal ultrasound can be used as the first-line investigation in the radiological evaluation of many bowel disorders. Ultrasound is the modality of choice for evaluation of appendicitis and is a valuable technique for initial assessment of bowel-related inflammatory conditions and bowel obstruction. Transabdominal ultrasound is of limited value in evaluating bowel neoplasms, although it can suggest the diagnosis. A diagnostic study is achieved with careful observation of the ultrasound appearances of the bowel wall and its immediate environment. BJHM

Conflict of interest: none.

Horsthuis K, Bipat S, Bennink RJ, Stoker J (2008) Inflammatory bowel disease diagnosed with US, MR, scintigraphy, and CT: meta-analysis of prospective studies. *Radiology* **247:** 64–79

Jeffrey RB, Jain KA, Nghiem HV (1994) Sonographic diagnosis of acute appendicitis: interpretive pitfalls. *AJR* **162:** 55–9

Kessler N, Cyteval C, Gallix B et al (2004) Appendicitis: evaluation of sensitivity, specificity, and predictive values of US, Doppler US, and laboratory findings. *Radiology* **230:** 472–8

Koichi Y, Shigeru S, Hiroya F, Shinji T, Masayuki F (2006) Transabdominal sonographic appearance of adult colonic polyps. *J Med Ultrason* **33:** 231–7

Kuzmich S, Howlett DC, Andi A, Shah D, Kuzmich T (2009) Transabdominal sonography in assessment of the bowel in adults. *AJR* **192:** 1–16

Ripollés T, Agramunt M, Martínez MJ, Costa S, Gómez-Abril SA, Richart J (2003) The role of ultrasound in the diagnosis, management and evolutive prognosis of acute left-sided colonic diverticulitis: a review of 208 patients. *Eur Radiol* **13:** 2587–95

KEY POINTS

- Ultrasound is a valid initial imaging technique in the radiological work-up of a wide spectrum of bowel abnormalities in adults.
- Graded compression improves diagnostic quality of the ultrasound study.
- Ultrasound is highly sensitive and specific in the diagnosis of acute appendicitis.
- Ultrasound is a valuable primary technique for imaging inflammatory conditions involving bowel.
- Ultrasound has a limited role in diagnosis and staging of bowel neoplasm, but clinically unsuspected intestinal tumours may be detected during a routine scan.