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Current Role of Ultrasound in Small Bowel Imaging

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Bowel ultrasound is cheap, relatively quick, allows dynamic evaluation of the bowel, has no radiation burden, is well tolerated by patients, and allows repeat imaging. Bowel ultrasound requires a systematic assessment of the entire bowel using high-frequency probes. In addition, hydrosonography and contrast-enhanced ultrasound may be performed. We present the normal sonographic appearances of large and small bowel and the sonographic appearances of acute appendicitis, Crohn's disease, celiac disease, intussusception, infectious enteritis, intestinal tuberculosis, small bowel ileus and obstruction, small bowel ischemia, and malignant tumors.

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Introduction

Despite recent advances in technology, endoscopic investigation of the small bowel remains challenging,[1] with imaging techniques now playing an increasingly crucial role in the diagnosis and monitoring of diseases of the small bowel. Although computed tomography (CT) and fluoroscopic studies remain the gold standard investigations,[2] both carry a significant radiation dose, so magnetic resonance imaging (MRI) and ultrasonography (US) are increasingly used as the first-line investigation, especially when imaging patients with inflammatory bowel disease where subsequent repeat imaging to monitor disease activity is useful, but the cumulative radiation dose from CT and fluoroscopic examinations is a concern.

Inevitably, local expertise has an influence on the techniques employed at individual institutions.[2] Magnetic resonance enterography provides a good assessment of the anatomy, bowel wall thickness, and extraintestinal disease, being able to distinguish between fibrosis and active inflammation with the employment of contrast-enhanced sequences. Assessment of mucosal detail, however, is limited, and the technique is relatively expensive and time consuming.

Alternatively, US is cheap, relatively quick, enables dynamic evaluation of the bowel, and can be employed in the acute setting; however, the diagnostic accuracy of the findings is operator dependent.[2] Acknowledging this, high-frequency sonography of the bowel, performed by an experienced operator, is invaluable in the assessment of patients with known or suspected small bowel pathology.

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Ultrasound Examination of the Bowel

Patient Preparation

US examination of the bowel is noninvasive, does not involve ionizing radiation, and is well tolerated and accepted by patients,[3] but a good examination requires skill and patience on the part of the operator.

As with all US examinations, the quality of the study can be hampered by large volumes of intraluminal gas.[1] Therefore, patient preparation focuses primarily on reducing this, by asking the patient to fast for at least 6 hours.[2] In addition, high-frequency US may have limited penetration in the obese patient[1]; however, in our experience, an adequate examination can often be achieved in this patient group, with graded compression of the abdomen, use of a midrange frequency transducer, preprocedural fasting, and hydrosonography.

Technical Requirements

Most modern US machines have the capability to perform a good diagnostic quality bowel ultrasound. Conventional transabdominal sonography should be performed before

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high-frequency sonographic assessment of the bowel. Although targeted bowel US is primarily used to assess the small bowel, the large bowel should also be examined for a complete examination.

Examination of the nondistended bowel should be performed with a high-frequency (5-17 MHz) probe.[2,4] Current consensus guidelines recommend that the examination be performed using linear arrays; however, we have found that performing most of the examination with a 4-10 MHz curvilinear array, followed by problem solving with a 6-12 MHz linear array, provides a good balance between adequate penetration, field of view, and spatial resolution, to enable a complete assessment of the bowel.

In our institution, we have optimized the machine presets for high-frequency sonography of the bowel for the range of transducers described earlier; however, an adequate examination of the bowel can be performed using the factory neonatal abdomen preset found on most machines.

A subjective assessment of mural and extraintestinal (ie, mesenteric) vascularity, using color or power Doppler imaging is often helpful,[4] but requires the operator to develop an appreciation of how normal vascularity of the bowel appears on their particular machine. This is especially important with the advent of new low-flow imaging software, such as Superb Microvascular Imaging[5]; here the increased sensitivity in detecting low velocity flow in small vessels may result in a tendency to overcall hypervascularity.

Some authors reported concerns that ultrasound may fail to adequately image the whole small bowel,[2,6] so a systematic approach to the examination is recommended.[2] The scanning technique requires small movements of the transducer, with gentle graded compression of the bowel, to displace intraluminal gas and improve the examination of the more posterior bowel wall.[7]

The ileocecal region, ascending, descending, and sigmoid colon are well visualized in most patients, whereas the examination of the jejunum, proximal ileum, and transverse colon can be more challenging.[2] In our experience, assessment of the proximal small bowel is often improved with hydrosonography (Fig. 1).

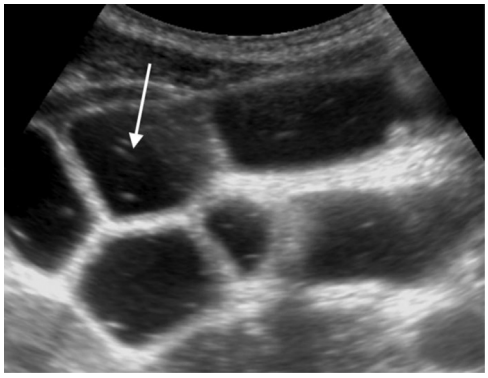

Figure 1 Hydrosonography—normal appearance of the ileum following oral contrast. The hypoechoic oral contrast distends the bowel lumen (arrow).

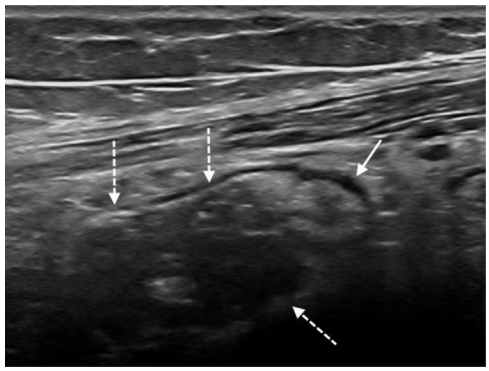

Figure 2 Normal longitudinal image of the terminal ileum (solid arrow) entering the cecum (dashed arrows).

Process of Examination

As already stated, conventional transabdominal ultrasound should be performed initially (unless already recently done) to assess for any extraintestinal cause which may account for the patient's symptoms.[4]

Targeted examination of the nondistended bowel should begin using either a midfrequency curvilinear or high-frequency linear array, depending upon patient's body habitus and availability. Starting in the right upper quadrant, the ascending colon is scanned in a TS orientation, from the hepatic flexure down to the cecum; the latter is identified by the termination of gas in the cecal pole. The cecal pole, terminal ileum, and appendix are then interrogated by scanning initially in a LS orientation to identify the structures, followed by a change in orientation appropriate to the positioning of the terminal ileum (TI) and appendix. Gentle graded compression can assist in identification of these structures. The terminal ileum should be followed into the cecal pole to ensure that it has been correctly identified. When scanning in plane to the length of the TI, fluid should be seen to distend the TI and enter the cecum (Fig. 2).

The remainder of the small bowel is then examined in a systematic approach to ensure it is completely visualized: we divide the abdomen into quadrants, whereas other authors have recommended scanning in overlapping parallel scan lines, either vertically or horizontally across the whole abdomen. A more targeted examination of the gastroesophageal

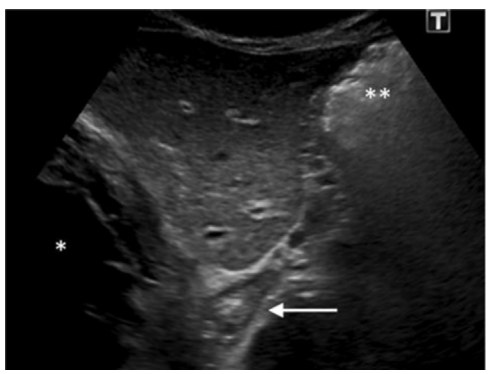

Figure 3 Gastroesophaeal junction scanned in LS (arrow), the heart is seen cranially (*), and gas within the stomach is seen caudally (**).