Pediatric Small Bowel Crohn Disease: Correlation of US and MR Enterography¹

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Abbreviations: FSE = fast spin echo, 3D = three-dimensional

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SA-CME LEARNING OBJECTIVES

After completing this journal-based SA-CME activity, participants will be able to:

- List the advantages and disadvantages of US versus CT enterography and MR enterography for evaluation of pediatric small bowel Crohn disease.
- Describe state-of-the-art US techniques for assessment of pediatric small bowel Crohn disease.
- Recognize US features of pediatric small bowel Crohn disease and related complications.

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Small bowel Crohn disease is commonly diagnosed during the pediatric period, and recent investigations show that its incidence is increasing in this age group. Diagnosis and follow-up of this condition are commonly based on a combination of patient history and physical examination, disease activity surveys, laboratory assessment, and endoscopy with biopsy, but imaging also plays a central role. Ultrasonography (US) is an underutilized well-tolerated imaging modality for screening and follow-up of small bowel Crohn disease in children and adolescents. US has numerous advantages over computed tomographic (CT) enterography and magnetic resonance (MR) enterography, including low cost and no required use of oral or intravenous contrast material. US also has the potential to provide images with higher spatial resolution than those obtained at CT enterography and MR enterography, allows faster examination than does MR enterography, does not involve ionizing radiation, and does not require sedation or general anesthesia. US accurately depicts small bowel and mesenteric changes related to pediatric Crohn disease, and US findings show a high correlation with MR imaging findings in this patient population.

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Introduction

Crohn disease affects more than 500,000 individuals in the United States, and about 25% of cases are diagnosed during the pediatric period (1). According to recent data, the incidence of Crohn disease in children and adolescents is increasing (1,2). The economic effects of pediatric and adult Crohn disease are staggering and are estimated to be between \$10.9 billion and \$15.5 billion per year in the United States alone (3). Diagnosis and follow-up of small bowel Crohn disease in children and adults are typically based on a combination of patient history and physical examination, disease activity surveys (eg, the Pediatric Crohn's Disease Activity Index), laboratory assessment, endoscopy with biopsy, and imaging (4).

Various imaging modalities can be used to diagnose and follow up pediatric small bowel Crohn disease, including radiography, fluoroscopic studies (eg, small bowel follow-through examination), computed tomography (CT), and magnetic resonance (MR) imaging (5,6). More recently, several authors have suggested that ultrasonography (US) can be used for screening and follow-up of small bowel Crohn disease in children (6–11). Technologic advances in US have allowed improved visualization of the small bowel and mesentery, especially in the pediatric population. One pediatric study

TEACHING POINTS:

- Technologic advances in US have allowed improved visualization of the small bowel and mesentery, especially in the pediatric population.
- A chief advantage of US compared with CT enterography and fluoroscopic studies is its lack of ionizing radiation.
- US examination of the bowel requires systematic assessment of all four abdominal quadrants as well as the pelvis.
- A single bowel wall thickness of 2.5–3 mm or more is considered abnormal and specific for diagnosis of Crohn disease in patients with suspected inflammatory bowel disease.
- Our research demonstrates that US accurately depicts bowel and mesenteric changes related to pediatric small bowel Crohn disease and that US findings have a high degree of correlation with MR imaging findings.

showed that patients with bowel wall thickening measured at US and positive laboratory findings (including elevated fecal calprotectin levels) have a greater than 99% probability of having inflammatory bowel disease (8). A chief advantage of US compared with CT enterography and fluoroscopic studies is its lack of ionizing radiation. Because pediatric patients with Crohn disease commonly require repeated imaging to assess disease activity, evaluate suspected complications, and guide medical and surgical management, repetitive imaging with ionizing modalities can result in considerable radiation exposure (5,12,13). Use of conventional gray-scale or Doppler US is safe, without risk of imaging-related complications or known contraindications, and it may be particularly valuable in settings where CT and MR imaging are contraindicated. US can also fill the void when these imaging modalities are not readily available. Tables 1 and 2 list the advantages and disadvantages of US compared with CT enterography and MR enterography for evaluation of pediatric small bowel Crohn disease.

This review describes US findings in the bowel and mesentery in children with small bowel Crohn disease. US images are presented alongside contemporaneous (same day, unless otherwise noted) correlative images from MR enterography. Many of the US images in this review were acquired as part of an ongoing institutional review board–approved research investigation; parental informed consent and subject informed assent were obtained as appropriate.

US Technique

Unlike CT enterography and MR enterography, small bowel US is generally performed without oral or intravenous contrast materials. No specific patient preparation is required, but carbonated beverages should probably be avoided before imaging (14). Although US is most often performed us-

Table 1: Advantages of US versus CT Enterography and MR Enterography in Pediatric Small Bowel Crohn Disease

Lower cost
Increased availability and accessibility versus MR enterography (and CT enterography in many parts of the world)
Nonionizing (unlike CT enterography)
Allows real-time imaging and assessment of peristalsis, unlike CT enterography
Potential for higher spatial resolution (with use of a high-frequency linear transducer) than MR enterography and CT enterography
Shorter examination time than MR enterography
No need for sedation, anesthesia, or antiperistaltic medication, unlike MR enterography
No need for oral or intravenous contrast material, unlike CT enterography and MR enterography

Table 2: Disadvantages of US versus CT Enterography and MR Enterography in Pediatric Small Bowel Crohn Disease

Operator dependent (variable reproducibility between operators and between examinations)
Incomplete visualization of the bowel (eg, bowel loops located in deep pelvis or bowel loops obscured by overlying structures or gas)
Smaller field of view and less panoramic than CT enterography and MR enterography
Limited data comparing diagnostic accuracy at US versus at CT enterography, MR enterography, and endoscopy for pediatric small bowel Crohn disease and disease-related complications

ing one or more high-frequency linear transducers (8–18 MHz), convex transducers with lower frequencies may be useful for visualizing bowel loops located deep within the abdomen or pelvis and for examining obese children. Graded compression of the anterior abdominal wall with the US transducer and manual posterior compression with the nonscanning hand can be used to displace or efface normal overlying air and fluid-filled bowel loops and bring abnormal bowel segments closer to the transducer for improved image quality (10,14).

US examination of the bowel requires systematic assessment of all four abdominal quadrants as well as the pelvis. The terminal ileum is specifically identified by its location in the right lower quadrant and its relationships to the ileocecal valve, proximal colon, appendix, psoas major muscle, and iliac vessels. Gray-scale and color or power Doppler US images (including cine clips) of abnormal bowel segments should be obtained in both the long and short axes. Gray-scale US

Figure 1. Normal terminal ileum in a 10-year-old boy. Long-axis gray-scale (a) and color Doppler (b) US images show the normal thin-walled terminal ileum (arrows) draped over the right iliac vessels (*). The lack of demonstrable blood flow seen in the terminal ileum in b is a normal finding. C = cecum.

Figure 2. Long-axis gray-scale ex vivo US image of a resected terminal ileal specimen from an adolescent with Crohn disease. Imaging was performed with the bowel resting on a standoff pad (*). The bowel wall is thickened, has a preserved stratified appearance, and is surrounded by the thickened echogenic mesentery (creeping fat). Bowel wall layers seen are the echogenic mucosa-lumen interface (1); the hypoechoic mucosa, including the muscularis mucosae (2); the echogenic submucosa (3); and the hypoechoic muscularis propria (4).

allows morphologic assessment of the bowel wall and mesentery, while Doppler US is used to assess bowel wall and mesenteric inflammation on the basis of hyperemia. Harmonic imaging, which relies on US performed at a higher frequency than the transmitted fundamental frequency (using a multiple of the transmitted fundamental frequency), can be used to improve axial and lateral spatial resolution, improve contrast resolution, and decrease artifacts (14). Panoramic imaging improves depiction of long and often tortuous abnormal bowel segments by extending the field of view (14). It has been suggested that this adjunct imaging technique may aid in measuring the length of diseased bowel segments (14).

Bowel Wall Findings

Normal Appearance of the Small Bowel

Normal small bowel loops typically have several characteristic US features. The normal small bowel

wall is generally paper thin (<2 mm) and is easily compressible with transducer pressure (Fig 1). The wall thickness of normal small bowel loops is often difficult to measure. Normal small bowel loops usually are closely apposed, show regular peristalsis, and are not fixed in place. Color or power Doppler US interrogation of normal small bowel loops shows absent or minimal intramural and perienteric signal intensity (with no evidence of hyperemia).

Mural Thickening

Bowel wall thickening is commonly observed in both active and chronic (including quiescent) small bowel Crohn disease (15) (Figs 2–6). A single bowel wall thickness of 2.5–3 mm or more is considered abnormal and specific for diagnosis of Crohn disease in patients with suspected inflammatory bowel disease (11). Bowel wall thickening may be concentric or eccentric, and the echogenic submucosal layer is often the thickest portion of the bowel wall (Figs 2, 3). While the bowel wall frequently has a stratified appearance at US (Figs 2, 3), altered bowel wall echogenicity (either abnormally hypo- or hyperechoic) with loss of stratification can be observed in cases of severe inflammation and/or fibrosis (Fig 5). Substantial bowel wall thickening in the setting of clinically inactive disease can be suggestive of mural fibrosis (15). Inflamed and fibrotic small bowel loops are generally noncompressible at US (14).

Figure 3. Terminal ileitis due to newly diagnosed Crohn disease in a 15-year-old male adolescent. (a) Long-axis gray-scale US image shows the thick-walled stratified terminal ileum (arrows) overlying the iliac vessels (*). The echogenic submucosa is the thickest layer of the bowel wall. The abnormal bowel segment can be seen despite the patient's large body habitus. (b) Axial single-shot fast spin-echo (FSE) MR image shows similar findings. The distal ileum (arrows) is seen immediately between the anterior abdominal wall and the right common iliac vessels.

Figure 4. Crohn disease involving the small and large bowel in a 6-year-old girl. (a) Long-axis gray-scale US image shows thickened small bowel loops (arrows) adjacent to the urinary bladder (*) with partial loss of mural layering. (b) Coronal contrast-enhanced fat-saturated T1-weighted three-dimensional (3D) MR image confirms long-segment active terminal ileitis with wall thickening, hyperenhancement, and vasa recta engorgement (arrows). The sigmoid colon in the left lower quadrant (arrowhead) is also inflamed.

Hyperemia

Inflamed small bowel segments typically show increased intramural signal intensity at color or power Doppler US because of increased blood flow (hyperemia) (Figs 7, 8). The sensitivity of Doppler US to depict blood flow in the bowel wall can be maximized by minimizing the pulse repetition frequency. At color Doppler US, increased density of bowel wall blood vessels is associated with increased inflammatory activity in Crohn disease (16). Recent investigations have shown that contrast-enhanced US with microbubble contrast agents can be used to objectively assess disease activity in adults with small bowel Crohn disease (17,18).

Abnormal Luminal Caliber

Areas of bowel wall thickening with persistent luminal narrowing are termed *strictures*. Immediate upstream (proximal) bowel dilatation with stasis of bowel contents suggests at least some degree of intestinal obstruction (Fig 9). Strictures vary in the degree of associated upstream dilatation and obstruction (ranging from minimally to severely obstructing), and the degree of obstruction can progress with time. At Doppler US, strictures that demonstrate hyperemia at the site of intestinal nar-

a.

b.

c.

a.

b.

Figure 6. Terminal ileitis in a 17-year-old girl with known Crohn disease. (a) Short-axis gray-scale US image through the right lower quadrant shows marked terminal ileal wall thickening (arrows), with a maximum wall thickness of 8 mm. (b) Axial single-shot FSE MR image confirms terminal ileal wall thickening (arrows).

rowing have an active inflammatory component (Fig 9), although underlying fibrosis can also be present (19). Strictures without increased blood flow at Doppler US are commonly fibrotic and are less likely to respond to medical therapy. A study of adults with Crohn disease showed that US was used to correctly identify strictures in 90% of affected patients who underwent surgery (63 true-positive, 15 true-negative, zero false-positive, and seven false-negative results) (20).

Altered Peristalsis

A major advantage of US is its real-time imaging capability, which allows detailed assessment of bowel peristalsis (which often is abnormal in small bowel Crohn disease). Both inflamed and fibrotic intestinal segments commonly show decreased peristalsis and often appear fixed in place. This observation has been confirmed in a recent MR imaging study by Menys et al (21), who showed that quantitative bowel motility negatively correlates

Figure 7. Terminal ileitis in a 10-year-old boy with newly diagnosed Crohn disease. **(a)** Color Doppler US image shows terminal ileal wall thickening, with markedly increased intramural signal intensity due to active inflammation. Extensive signal aliasing is also seen. **(b)** Axial diffusion-weighted MR image confirms marked bowel wall inflammation (arrows). The hyperintense appearance of the bowel wall is due to restricted diffusion of water.

Figure 8. Terminal ileitis in a 14-year-old girl. **(a)** Color Doppler US image shows mild terminal ileal wall thickening and marked intramural hyperemia due to active inflammation. The terminal ileum overlies the right iliopsoas muscle (arrow) and iliac vessels (*). **(b)** Axial fat-saturated single-shot FSE MR image shows 15 cm of mildly thickened distal and terminal ileum (circled), a finding that avidly enhanced at contrast-enhanced MR imaging (not shown). Arrow = right iliopsoas muscle, * = iliac vessels.

with histopathologic and other radiologic indicators of disease activity. A study by Froehlich et al (22) that included cine MR imaging suggests that US findings of altered peristalsis could be used to increase detection of abnormal bowel segments. In our experience, segments of dilated bowel located immediately upstream to obstructing strictures can exhibit either hypo- or hyperperistalsis.

Mesenteric Findings

Inflammation

Mesenteric inflammation is commonly observed in children with active small bowel Crohn disease. Gray-scale US may reveal mesenteric thickening with areas of heterogeneous echogenicity due to edema, while color or power

Doppler US may show increased mesenteric blood flow, including the “comb” sign due to vasa recta engorgement (Figs 10, 11). A CT study by Lee et al (23) showed that prominent perienteric vasculature is associated with active disease and that this finding is associated with the need for more aggressive medical management. Again, the sensitivity of Doppler US for detection of mesenteric hyperemia can be maximized by minimizing the pulse repetition frequency. Rarely, mesenteric septic thrombophlebitis may be observed in the setting of small bowel Crohn disease. When mesenteric venous thrombosis is noted, the liver should be carefully evaluated for abscesses (24). Spectral Doppler US has also been used to assess the mesenteric vasculature in patients with Crohn disease,

Figure 9. Stricture in a 15-year-old boy with newly diagnosed Crohn disease. (a) Long-axis gray-scale US image shows an obstructing stricture. The terminal ileum is thick walled (arrows) with luminal narrowing, while the more proximal small bowel is dilated and contains debris (*). (b) Short-axis power Doppler US image shows the narrowed bowel segment with marked hyperemia due to active inflammation. * = iliac artery. (c, d) Coronal single-shot FSE MR images obtained at different levels confirm small bowel obstruction, with a thickened narrowed terminal ileum (arrow) and proximal luminal dilatation (* in c).

Figure 10. Active terminal ileitis in a 14-year-old boy. (a) Color Doppler US image shows a thickened loop of small bowel (arrows) in the right lower quadrant, with adjacent mesenteric hyperemia and fibrofatty proliferation. (b) Axial fat-saturated single-shot FSE MR image shows numerous engorged vessels (circled) in the right lower quadrant of the small bowel mesentery adjacent to the terminal ileum.

Figure 11. Active terminal ileitis in a 5-year-old boy. **(a)** Short-axis gray-scale US image shows small bowel wall thickening (arrows) in the right lower quadrant and adjacent free fluid (*) that is likely reactive. **(b)** Long-axis color Doppler US image shows marked bowel wall and mesenteric hyperemia and the “comb” sign.

Figure 12. Terminal ileitis in a 10-year-old boy with newly diagnosed Crohn disease. **(a)** Short-axis gray-scale US image shows the thick-walled heterogeneous terminal ileum in the right lower quadrant. The adjacent small bowel mesentery is markedly thickened and echogenic, a finding due to fibrofatty proliferation (*). The adjacent bowel loops are displaced. **(b)** Axial single-shot FSE MR image shows similar findings. The increased signal intensity surrounding the terminal ileum is due to creeping fat (*).

although some researchers have concluded that spectral Doppler US findings do not reliably correlate with disease activity (11,25).

Fibrofatty Proliferation

Increased amounts of mesenteric fibrofatty tissue are commonly observed adjacent to small bowel segments affected by Crohn disease. Although this phenomenon, also called *creeping fat* or *fat wrapping*, likely increases with increasing disease chronicity, it is commonly seen at initial presentation. At gray-scale US, mesenteric fibrofatty proliferation appears as an abnormally thickened echogenic mesentery that displaces adjacent bowel loops because of mass effect (Fig 12) (14). A recent study by Kredel et al (26) indicates that hypertrophic mesenteric fat serves as a barrier with the potential to limit intestinal inflammation and that associated adipokines play a role in modulating immune responses.

Regional Lymphadenopathy

Enlarged intra-abdominal lymph nodes in pediatric patients with small bowel Crohn disease are most often reactive, although on occasion they may be due to infection or a neoplasm (eg, lymphoma). Regional lymphadenopathy due to Crohn disease may manifest as an increased number of visualized lymph nodes and/or increased lymph node size (Figs 13, 14) and occasionally as a nodal conglomerate mass (27). Typically, reactive lymph nodes are located along the expected lymphatic drainage pathway of an inflamed bowel segment, are hypoechoic and round or oval, and retain an appreciable fatty hilum, even when enlarged (Fig 14). Increased intranodal signal intensity at color or power Doppler US may be observed. A recent study of more than 1300 patients with inflammatory bowel disease (mean age at diagnosis, 12.1 years) showed that lymphadenopathy is only rarely

Figure 13. Small bowel Crohn disease in a 10-year-old boy. **(a)** Gray-scale US image shows a mildly enlarged, 9-mm, likely reactive lymph node (arrows) in the small bowel mesentery. **(b)** Axial fat-saturated single-shot FSE MR image shows extensive signal intensity abnormality in the right lower quadrant (circled) due to inflammation, which obscures typically hyperintense lymph nodes.

Figure 14. Crohn disease in a 7-year-old boy. **(a)** Gray-scale US image shows an enlarged, likely reactive lymph node (arrows) in the small bowel mesentery just anterior to the right psoas muscle. The fatty hilum of the lymph node is preserved. **(b)** Axial diffusion-weighted MR image depicts the same lymph node (arrow).

due to lymphoma, as only two cases of lymphoma were identified (28).

Sinus Tracts and Fistulas

Sinus tracts and fistulas represent penetrating complications of small bowel Crohn disease. Some researchers have hypothesized that these particular complications are in part due to increased intraluminal pressure because sinus tracts and fistulas often arise from or just proximal to intestinal strictures. Small bowel fistulas are inflammatory tracts that communicate with a second epithelialized structure (eg, another small bowel loop or the colon, appendix, urinary bladder, or skin), while sinus tracts are blind-ending structures. At gray-scale US, these penetrating tracts appear as linear areas of altered echogenicity (most often hypoechoic, although they may contain echogenic

gas or debris) arising from the serosal surface of the intestine (Fig 15) (29). At color or power Doppler US, increased signal intensity in the wall of penetrating tracts has also been described (30). Affected bowel loops may appear tethered or angulated. In a large prospective study of adults, US depicted 71.4% of internal fistulas that were identified intraoperatively (29). Unfortunately, there is a paucity of data in the literature regarding the sensitivity and specificity of US for detection and characterization of intra-abdominal penetrating complications in children.

Abnormal Fluid

Free Fluid.—Intraperitoneal free fluid is common in pediatric small bowel Crohn disease and is generally considered reactive in etiology. Free fluid

Figure 15. Penetrating stricturing Crohn disease in a 19-year-old woman. (a, b) Coronal (a) and axial (b) contrast-enhanced fat-saturated T1-weighted 3D MR images obtained 1 week before surgery show a fistula between the terminal ileum (arrows) and the appendix (arrowhead). (c, d) Gray-scale US images of the resected bowel specimen show a fistula tract between the thick-walled terminal ileum (arrows) and the appendix (arrowheads). Fibrofatty thickening of the mesentery is also seen.

due to Crohn disease may be difficult to discriminate from physiologic free fluid, particularly in girls. At gray-scale US, free fluid may be seen immediately adjacent to inflamed bowel loops (Figs 16, 17) or in dependent locations, such as the paracolic gutters, hepatorenal fossa, or deep pelvis. Free fluid may be simple (appearing anechoic) or complicated, with debris or occasional septations.

Phlegmon.—*Phlegmon* in the setting of small bowel Crohn disease refers to acute suppurative inflammation of the soft tissues adjacent to an inflamed bowel segment. This includes poorly organized fluid collections that lack a discernable wall. Areas of phlegmon probably arise from focal bowel wall perforations (eg, sinus tracts or fistulas). These areas typically are hypoechoic at gray-scale US, lack a discrete wall (unlike abscesses), and may demonstrate associated hyperemia at color or power Doppler US (Fig 18). A recent study by Ripollés et al (31)

shows that contrast-enhanced US performed after intravenous microbubble contrast material injection can be used to accurately differentiate areas of intra-abdominal phlegmon from abscess according to the pattern of enhancement, with a high degree of specificity.

Abscess.—Abscesses are discrete, organized, infected fluid collections that typically are located adjacent to actively inflamed bowel loops. Similar to phlegmons, abscesses are thought to be the result of focal bowel wall perforation. At gray-scale US, abscesses appear as walled-off focal fluid collections. These collections may have variable internal echogenicity and may contain substantial internal debris, septations, and even nondependent echogenic gas. Abscesses may contain large amounts of gas with associated posterior shadowing or reverberation artifact, and they can be mistaken for an air-filled bowel loop (Fig 19). Similarly, abscesses containing

Figure 16. Crohn disease in an 18-year-old woman. (a) Short-axis gray-scale US image shows marked terminal ileal wall thickening and adjacent, likely reactive, free fluid (arrows). (b) Axial fat-saturated single-shot FSE MR image confirms severe terminal ileitis with bowel wall thickening, mural edema, and adjacent mesenteric inflammation. A small amount of free fluid (arrow) is seen adjacent to the terminal ileum.

Figure 17. Crohn disease in a 4-year-old boy. (a) Short-axis gray-scale US image shows terminal ileal wall thickening (arrows) and adjacent free fluid (*). (b) Coronal single-shot FSE MR image shows wall thickening in the terminal ileum and a small amount of adjacent free fluid (arrow). The free fluid is more easily appreciated at US.

relatively simple fluid may be confused with a fluid-filled bowel loop (or vice versa) (Fig 20) (7). Color or power Doppler US interrogation of abscesses reveals peripheral hyperemia with absent blood flow centrally. In a large study of adults with Crohn disease, US was used to correctly identify 91% of intra-abdominal abscesses, although a few false-positive findings were observed (29).

Conclusion

Our research demonstrates that US accurately depicts bowel and mesenteric changes related to pediatric small bowel Crohn disease and that US findings have a high degree of correlation with MR imaging findings. Because of the numerous advantages and few disadvantages of US com-

pared with CT enterography and MR enterography, we believe that US should be considered a viable imaging modality for assessment of Crohn disease, at both initial screening and follow-up of known small bowel and mesenteric involvement in children. Additional prospective investigations are needed to ascertain the exact diagnostic performance characteristics (eg, sensitivity and specificity) of US in pediatric small bowel Crohn disease compared with state-of-the-art CT enterography, MR enterography, and endoscopy.

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Figure 18. Terminal ileitis due to Crohn disease in a 14-year-old girl. (a) Long-axis gray-scale US image shows an ill-defined area of decreased echogenicity (arrows) between an inflamed bowel loop (arrowheads) and the anterior abdominal wall (*), a finding consistent with phlegmon. (b, c) Axial contrast-enhanced fat-saturated T1-weighted 3D MR images obtained at different levels show marked terminal ileal wall thickening and hyperenhancement (arrowheads). The ill-defined perienteric soft-tissue enhancement adjacent to the terminal ileum (arrows) is consistent with phlegmon and is likely the result of penetrating Crohn disease. No drainable fluid component was identified.

a.

b.

c.

a.

Figure 19. Abscess in an 11-year-old girl with known Crohn disease and worsening abdominal pain. (a) Gray-scale US image shows terminal ileal wall (arrows) and mesenteric thickening. A curvilinear gas-filled structure (arrowheads) in the anterior abdomen is a large abscess but could be mistaken for a bowel loop. (b, c) Axial fat-saturated single-shot FSE MR image (b) and contrast-enhanced fat-saturated T1-weighted 3D MR image (c) show a large, peripherally enhancing, gas-containing abscess (arrowheads) in the small bowel mesentery. The thick-walled narrowed terminal ileum (arrows) is difficult to visualize because of surrounding inflammation. A dilated debris-filled bowel loop (*) in the left lower quadrant is due to the obstructed small bowel.

b.

c.

Figure 20. Abscess in a 16-year-old girl with newly diagnosed Crohn disease. (a) Transverse gray-scale US image shows a 3-cm hypoechoic fluid collection (arrows) in the greater omentum, located just deep to the abdominal wall musculature (*). (b, c) Axial (b) and coronal (c) contrast-enhanced fat-saturated T1-weighted 3D MR images show extensive inflammation of the greater omentum and small bowel mesentery. A peripherally enhancing round structure (arrow) located just deep to the abdominal wall musculature (* in b) corresponds to the abnormality seen in a. This small focal abscess is better appreciated at US than at MR imaging.

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