Consensus Recommendations for Evaluation, Interpretation, and Utilization of Computed Tomography and Magnetic Resonance Enterography in Patients With Small Bowel Crohn’s Disease

Computed tomography and magnetic resonance enterography have become routine small bowel imaging tests to evaluate patients with established or suspected Crohn’s disease, but the interpretation and use of these imaging modalities can vary widely. A shared understanding of imaging findings, nomenclature, and utilization will improve the utility of these imaging techniques to guide treatment options, as well as assess for treatment response and complications. Representatives from the Society of Abdominal Radiology Crohn’s Disease-Focused Panel, the Society of Pediatric Radiology, the American Gastroenterological Association, and other experts, systematically evaluated evidence for imaging findings associated with small bowel Crohn’s disease enteric inflammation and established recommendations for the evaluation, interpretation, and use of computed tomography and magnetic resonance enterography in small bowel Crohn’s disease. This work makes recommendations for imaging findings that indicate small bowel Crohn’s disease, how inflammatory small bowel Crohn’s disease and its complications should be described, elucidates potential extra-enteric findings that may be seen at imaging, and recommends that cross-sectional enterography should be performed at diagnosis of Crohn’s disease and considered for small bowel Crohn’s disease monitoring paradigms. A useful morphologic construct describing how imaging findings evolve with disease progression and response is described, and standard impressions for radiologic reports that convey meaningful information to gastroenterologists and surgeons are presented.

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This article is being published jointly in Radiology and Gastroenterology.

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©2018, RSNA, AGA Institute, and Society of Abdominal Radiology
Computed tomography enterography (CTE) and magnetic resonance enterography (MRE) have emerged as the most effective methods for imaging the small bowel in patients with Crohn’s disease (1,2). Cross-sectional enterography techniques complement ileocolonoscopy and can visualize intramural or proximal small bowel inflammation in approximately 50% of Crohn’s disease patients who have endoscopically normal examinations (3–5). CTE and MRE are useful tools for Crohn’s disease diagnosis, determining distribution of disease involvement, and detecting complications of the disease (1,2). Recent data suggest that cross-sectional imaging may be useful in determining response to therapy, assessing bowel healing, and monitoring disease progression (6). The Society of Abdominal Radiology (SAR) formed a Crohn’s Disease-Focused Panel, which has established standards for the technical performance of these examinations (Appendix 1) (7–9). CTE and MRE are now performed across a range of institutions, with the radiologic literature focusing on the technical aspects of diagnosis and identification of mural inflammation or penetrating complications, such as fistula and abscess, using various acquisition methods and imaging findings. Important prior consensus statements, including those of the European Crohn’s and Colitis Organization and European Society of Gastrointestinal and Abdominal Radiology and SAR, establish critical and necessary rationale for when and how imaging of inflammatory bowel disease patients should be performed, respectively (2,7,8). To date, however, there are no agreed-upon expectations for structures that should be evaluated at cross-sectional enterography, no standardized nomenclature for describing imaging findings in Crohn’s disease, no guidance for how to describe severity and burden of different Crohn’s disease imaging findings to best guide medical and surgical management, and no consensus between US gastroenterology and radiology societies on when these tests should be performed. The purpose of this work is to establish a common system for mapping specific imaging findings to clinically useful impressions and for description of Crohn’s disease phenotypes that can guide gastroenterologists and surgeons in making important treatment decisions for Crohn’s disease patients. The standardization will both advance patient care through improved understanding of the communicated imaging findings and improve comparison of reported research in the field.

Because CTE and MRE findings change patient management in a substantial proportion of symptomatic patients (10,11), systematic review of CTE and MRE images is essential to maximize patient benefit. A motivating example for how a systematic review of imaging findings and standard nomenclature might improve patient care can be found in the standard reporting template for pancreatic cancer: an interdisciplinary group of radiologists, medical oncologists, pancretologists, and pancreatic surgeons recommended a systematized reporting template for pancreatic carcinoma, designed to capture objective imaging findings to guide and improve therapeutic decisions (12). In Crohn’s disease, the use of imaging is evolving over time. Cross-sectional imaging was initially used to detect and stage Crohn’s disease (5), but it is increasingly being used to gauge therapeutic response (4,13), providing objective measures to guide treatment decisions that can potentially alter the natural history of the disease (14). Mucosal healing as detected by colonoscopy in Crohn’s disease results in improved outcome (15–18); however, more recently, cross-sectional imaging, primarily MRE, has demonstrated a high correlation between mucosal healing at endoscopy and transmural healing at cross-sectional imaging, with improved outcomes when detected (19–21). Thus, there needs to be a shared understanding of the goals of imaging between referring clinicians and radiologists: while numerous investigators have consequently examined the relationship between objective and subjective imaging findings and the severity of endoscopic and histologic inflammation (4,22–25), others have described the extent of intestinal damage using cross-sectional findings (26). Information conveying length of involvement, severity of inflammation or bowel dilation, and surgical resections are required when assessing for therapeutic response.

While the existing Montreal classification (and pediatric Paris classification) sub-classify phenotypes of Crohn’s disease, including nonstrictureing and nonpenetrating inflammatory disease; stricturing disease; penetrating complications; and perianal fistula (27,28), they do not describe the length and severity of inflammatory involvement or the anatomic relationship of coexisting phenotypes that are necessary to make important surgical and medical management decisions. More specifically, the Montreal/Paris classifications do not take into account the dynamic continuum of the disease, the overlap or co-existence of stricturing and penetrating disease (2 separate types of disease complications occurring from disease progression) (29,30), or the fact that active inflammation is most often present in stricturing complications (22,29,31). Both CTE and MRE can detect the morphologic continuum and co-existing “complications” with regularity, thus prompting the need for radiologists to reliably define and...
## Table 1
### Imaging Findings Associated With Small Bowel Crohn’s Disease Inflammation

<table>
<thead>
<tr>
<th>Imaging findings</th>
<th>Description/definition</th>
<th>DDX considerations/comments</th>
<th>Conclusions (level of evidence)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Segmental mural hyperenhancement</td>
<td>Increased attenuation/signal intensity on contrast-enhanced scan in noncontracted segment in comparison to nearby normal small bowel segments</td>
<td>Predictive but nonspecific sign (36,41)</td>
<td>1. Segmental mural hyperenhancement and wall thickening have a moderately high sensitivity and specificity for small bowel Crohn’s disease at CTE or MRE (37–40). (Moderate)</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Causes include Crohn’s disease-related mural inflammation, backwash ileitis, infectious enteritis, mucositis, graft-vs-host disease, contraction or underdistension, radiation enteritis, NSAID enteropathy, angioedema, vasculitis, and ischemia</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>Altered enhancement in Crohn’s disease can also reflect processes other than inflammation, such as fibrosis or chronic mesenteric venous occlusion</td>
<td>2. Mural hyperenhancement without wall thickening is a nonspecific imaging sign, and may reflect inflammation or other processes (24,37,40,41). (Moderate)</td>
</tr>
<tr>
<td></td>
<td></td>
<td>More likely indicates Crohn’s disease when asymmetric and combined with other mural and mesenteric findings below</td>
<td>3. CTE and MRE may detect small bowel inflammation not seen at ileocolonoscopy (3,5,75). (Moderate)</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Contrast-enhanced imaging is performed in enteric to portal phases of enhancement (7,8)</td>
<td>4. CTE and MRE with only oral contrast will not detect or stage colonic inflammation as well as ileocolonoscopy (75–77). (Moderate)</td>
</tr>
<tr>
<td>Asymmetric</td>
<td>Asymmetric in cross-sectional or longitudinal direction compared to the lumen Mesenteric border is often more affected than antimesenteric border</td>
<td>Specific finding for Crohn’s disease (41)</td>
<td>5. Hyperintense T2-weighted signal and restricted diffusion at MR enterography is correlated with moderate to severe endoscopic inflammation (25,37,78–80). (Moderate)</td>
</tr>
<tr>
<td>Stratified (bi- or tri- laminar)</td>
<td>Inner-wall hyperenhancement or halo sign</td>
<td>Can refer to morphologic pattern of hyperenhancement, wall thickening or stratification</td>
<td>6. Unenhanced MR enterography with diffusion-weighted imaging has a moderate sensitivity and specificity for detection of ileal Crohn’s disease (25,49,81,82). (Moderate)</td>
</tr>
<tr>
<td>Homogeneous, symmetric</td>
<td>Transmural hyperenhancement</td>
<td>Can be due to many other causes including edema, collagen deposition, infiltration, ischemia, shock bowel</td>
<td></td>
</tr>
<tr>
<td>Wall thickening</td>
<td>Only measured or estimated in bowel loops distended by enteric contrast</td>
<td>Measure the thickest portion of most distended segment or site of most severe inflammation</td>
<td></td>
</tr>
<tr>
<td>Mild</td>
<td>3–5 mm (23,24,26,41)</td>
<td>Look for signs of tumor for focal stenoses &gt;1.5 cm in diameter—mass, extension into adjacent mesentery (3,59,83,84)</td>
<td></td>
</tr>
<tr>
<td>Moderate</td>
<td>5–9 mm</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Severe</td>
<td>≥10 mm (22)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Imaging Findings</td>
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<tr>
<td>Intramural Edema</td>
<td>Hyperintense on fat-saturated T2-weighted images; only on MR (cannot comment on intramural edema with CT) (24)</td>
<td>In comparison to normal small bowel, increased hyperintensity on T2-weighted images is associated with more severe inflammation (24). In regions of Crohn’s disease-related inflammation on gadolinium-enhanced images, increased diffusion-weighted signal abnormality is associated with more severe inflammation (25).</td>
<td>7. Most Crohn’s disease strictures have both inflammation and fibrosis (22,53,54,56). (High)</td>
</tr>
<tr>
<td>Stricture</td>
<td>Luminal narrowing in area of Crohn’s disease with unequivocal upstream dilation</td>
<td>Location and length should be described for potential subsequent surgical or endoscopic intervention. Remember that strictures also arise from NSAID and radiation enteropathy, and adhesions can mimic Crohn’s disease strictures (85).</td>
<td>8. A stricture is present when the lumen is narrowed, and there is proximal small bowel dilation (31,53,54,76,86). (High)</td>
</tr>
<tr>
<td>Without upstream dilation</td>
<td>Upstream lumen &lt; 3 cm When multiple pulse sequences, fluoroscopic observation, or serial imaging exams demonstrated fixed narrowing without upstream dilation, it is appropriate to describe that a probable stricture is present.</td>
<td>Degree of upstream dilation can be highly variable based on many factors including chronicity, ingested material, Focal reduction in luminal diameter despite adequate enteric contrast in a bowel loop with imaging findings of Crohn’s disease</td>
<td>9. Proximal small bowel dilation may correlate with a higher burden of fibrotic disease (22,31,53,54,87). (Low)</td>
</tr>
<tr>
<td>With mild upstream dilation</td>
<td>Upstream lumen 3–4 cm</td>
<td>When present, careful assessment of the transition point should be performed in order to determine the cause of the bowel obstruction. Differential diagnosis includes a Crohn’s stricture (with or without imaging findings of inflammation), adhesive disease and tumor; when moderate to severe may be appropriate to state in Impression “small bowel obstruction.”</td>
<td>10. CTE and MRE can detect unsuspected small bowel strictures in Crohn’s disease patients (11,88). (Low)</td>
</tr>
<tr>
<td>With moderate to severe upstream dilation</td>
<td>Upstream lumen &gt; 4 cm</td>
<td>When present, careful assessment of the transition point should be performed in order to determine the cause of the bowel obstruction. Differential diagnosis includes a Crohn’s stricture (with or without imaging findings of inflammation), adhesive disease and tumor; when moderate to severe may be appropriate to state in Impression “small bowel obstruction.”</td>
<td></td>
</tr>
<tr>
<td>Ulcerations</td>
<td>Appear as small focal breaks in the intraluminal surface of the bowel wall with focal extension of air or enteric contrast into the inflamed bowel wall Do not extend beyond the bowel wall</td>
<td>When seen at cross-sectional imaging, correlates with severe endoscopic inflammation (4,23). Avoid the term penetrating ulcer so that it is not confused with penetrating disease, such as fistula or abscess.</td>
<td>11. Visualization of ulcers at cross-sectional enterography is a marker of severe inflammation (4,20,23,89). (High)</td>
</tr>
<tr>
<td>Sacculations</td>
<td>Broad-based outpouchings that occur along the anti-mesenteric border due to acute or chronic mesenteric border inflammation</td>
<td>Sequela of asymmetric mural inflammation with shortening of the gut along the mesenteric border</td>
<td></td>
</tr>
<tr>
<td>Diminished motility</td>
<td>Alerts radiologist to locations of potential disease</td>
<td>Rely on conventional imaging features of intestinal inflammation for diagnosis and severity assessment. Cine balanced steady state free precession imaging can display peristalsis and may be helpful in improving confidence in diagnosis of inflammation or stricture.</td>
<td>12. Altered motility can be helpful in identifying Crohn’s inflammation (90–93). (Moderate)</td>
</tr>
</tbody>
</table>

Note.—Items in boldface are required descriptive terms that should be used when present. Conclusions are based on criteria identified in the methods, with the level of evidence summarized accordingly as very low, low, moderate, or high. DDX, differential diagnosis; NSAID, nonsteroidal anti-inflammatory drug.
Methods

The SAR Crohn’s Disease-Focused Panel was established in March 2014 to disseminate knowledge and improve the quality and availability of small bowel and Crohn’s disease imaging techniques, with an overall aim to improve the care of patients with Crohn’s disease. After approval from the SAR Board of Directors and the American Gastroenterological Association’s (AGA) Institute Council, this panel met with representatives from the AGA’s Imaging and Advanced Technology section in person, via e-mail, and through conference calls, to develop a shared understanding of imaging findings across enterography techniques and their physiologic

reproducibly describe the anatomic burden of inflammation and Crohn’s disease complications.

These recommendations define imaging findings that should be evaluated, how disease burden should be described, and pathophysiologic conclusions that will improve the ability of gastroenterologists and intestinal surgeons to best make management decisions. For example, radiologists should examine for Crohn’s disease strictures, which are defined in this guideline as small bowel segments with luminal narrowing and unequivocal proximal (upstream) dilation. Moreover, these recommendations emphasize that when strictures are found, the length of the stricture and radiologic findings of concurrent inflammation and obstruction should be described. These elements provide much of the critical information a gastroenterologist will need to consider in determining options for medical, surgical, or endoscopic therapy. The benefits of a shared understanding and improved communication of cross-sectional enterography examinations will facilitate:

1. Improved use of imaging to guide treatment options, and assess for therapeutic response.
2. Improved understanding for how to compare and assess Crohn’s inflammatory burden.
3. Improved systematic assessment of important complications.
4. Improved ability to track and understand the natural history of Crohn’s disease.

Figure 1: Imaging-based morphologic construct that demonstrates the role of mural inflammation in driving small bowel Crohn’s disease and its stricturing and penetrating complications. Mild nonspecific mural inflammation can progress into asymmetric disease with greater and more characteristic mucosal and mural inflammation. Similarly, small bowel loops affected by active inflammatory small bowel Crohn’s disease can progress to stricturing and penetrating complications, revert to normal in appearance, or have residual sequela of prior inflammation, such as asymmetric mural fat and pseudosacculation, but without imaging signs of inflammation.
substrates. Representatives with expertise in Crohn’s disease were also sought and included from the Society of Pediatric Radiology, the European Society of Gastrointestinal and Abdominal Radiology, the Society for Surgery of the Alimentary Tract, the American Society of Colon and Rectal Surgeons, and the North American Society for Pediatric Gastroenterology, Hepatology and Nutrition. Through electronic communications and conference calls, consensus recommendations were reached and submitted to the SAR Board and AGA Council for approval.

A primary aim of this work was to define and describe key imaging findings that relate to the diagnosis, severity, and type of Crohn’s disease involvement in the small bowel. To this end, the evidence of Crohn’s disease inflammation for specific imaging findings at CTE and MRE was evaluated according to the GRADE (Grading of Recommendations Assessment, Development and Evaluation) system for evaluation of diagnostic tests (32–34). For this purpose, CTE and MRE were not considered as standalone tests, but as part of an imaging strategy combined with clinical assessment and ileocolonoscopy (32). In developing these recommendations, authors from the SAR Crohn’s Disease-Focused Panel and the AGA’s Imaging and Advanced Technology section reviewed original investigations and meta-analyses from the medical literature relating to each imaging finding. Practical conclusions were reached relating to each imaging finding reviewed, with the quality of the evidence for each conclusion graded along a 4-point scale (ie, very low, low, moderate, high) based on formalized, agreed-upon evaluation criteria: high-quality studies were those that enrolled consecutive patients in a clinically relevant cohort, with universal application of an endoscopic or histologic reference standard, clear blinding of readers, and site-specific correlation between reference and reader findings. Quality was downgraded if these criteria were not met, if there was substantial variation between studies without a clear explanation, or if there was major uncertainty about the effect of false positives and negatives. Conclusions for the level of evidence relating to each imaging finding were proposed by each pair of reviewers along with their assessment of the formalized criteria for evaluating the scientific evidence, with final agreement by consensus of panel and section members, respectively. Based on these conclusions, recommendations for use of CTE or MRE or incorporation of each imaging finding into a clinical report were created by the entire author group, with strong recommendations indicating confidence that incorporation will have desirable effects on patient outcomes and outweigh undesirable effects or alternatives (35). The strength of the recommendation also takes into account alternative management strategies. All authors then approved the final document by consensus. Subsequently, this document was submitted to the AGA Institute Council, the Board of Directors for SAR, and the Society of Pediatric Radiology, all of which approved the document.

**Imaging Findings**

Table 1 defines and describes imaging findings of mural inflammation at CTE and MRE, along with important diagnostic considerations and practical conclusions. Figure 1 pictorially illustrates...
an imaging-based morphologic construct that demonstrates the role of mural inflammation in driving Crohn’s disease exacerbations and response as seen at cross-sectional enterography, and which will be explained in greater depth after individual imaging findings have been reviewed. The pictorial representation of a single bowel loop is used to facilitate a unified understanding of how mural inflammation can change independent of signal properties of cross-sectional imaging modalities. Multiple studies have shown that in patients with Crohn’s disease, imaging findings of inflammation are strongly associated with the presence of histologic inflammation (36–40).

Evidence describing and supporting the use of these imaging findings for small bowel inflammation is provided in references within Table 1. By extension and inference, similar findings can reflect enteric inflammation in the stomach and colon.

While the co-existence of segmental hyperenhancement and wall thickening are used in combination as imaging findings reflecting Crohn’s disease inflammation (40,41), a number of other conditions can result in these imaging findings even when segmental involvement is multifocal (42,43). Additionally, other imaging findings often seen in small bowel Crohn’s disease inflammation, such as mural stratification and intramural edema, can also be seen in a number of other conditions. Asymmetric inflammation in the bowel wall in Crohn’s disease is commonly more severe along the mesenteric border and is probably a specific feature in Crohn’s disease (Figure 2) (44). The co-existence of mural inflammation and penetrating complications should also suggest Crohn’s disease, in the absence of other known causes of penetrating complications, such as appendicitis, diverticulitis, tumor, and tuberculosis. Given these considerations, radiologists should diagnose inflammatory small bowel Crohn’s disease either in known Crohn’s disease patients when the nonspecific imaging findings of
thickening of 3–5 mm and rarely causes luminal narrowing. Severe inflammation is present if ulcerations or high T2 intramural signal are identified (Figures 3 and 5). Restricted diffusion is a non-specific sign of Crohn’s disease mural inflammation, but when other typical findings of mural inflammation are present on contrast-enhanced and/or T2-weighted images, restricted diffusion is a complementary and supportive finding that has been shown to correlate with severe inflammation at endoscopy (25). Restricted diffusion is present when intramural hyperintensity is present on high b-value images (often similar to reactive lymph nodes), and should prompt a careful assessment for other signs of severe inflammation. However, radiologists should be aware that false positives on diffusion-weighted imaging can be due to many factors, including suboptimal fluid distention. For example, the normal jejunum demonstrates increased relative nonfocal restricted diffusion in comparison to the normal ileum. The diagnosis of active Crohn’s disease should not be made on the basis of restricted diffusion alone (46,48).

Multiple MR-based scoring systems that describe inflammatory severity have been developed based on measures of histologic or endoscopic inflammation and rely on the described visual observations (eg, ulcers, intramural hypointense T2 signal) and/or quantitative measurements (eg, wall thickness, relative contrast enhancement). Scoring systems, such as MaRIA, Clermont score, and MEGS, differ in the imaging findings evaluated and the potential weighting given to each finding or measurement, and are used in clinical studies to quantitate improvement or worsening of active inflammatory Crohn’s disease (4,23,24,49–51). The advantage of the severity scoring systems is that they integrate imaging findings in a systematic and reproducible manner. When transmural healing occurs or penetrating complications develop at CTE/MRE after therapy, however, cross-sectional images clearly demonstrate information that can be quickly assessed and conveyed without performing systematic scoring. Moreover, scoring systems do

Figure 5: Imaging findings of severe inflammation of the terminal ileum at MRE, as indicated by marked wall thickening (top left, arrow), intramural edema or hyperintensity on a T2-weighted image with fat saturation (top right, arrow), increased intramural signal on high b-value diffusion-weighted images (bottom left, arrow), and small ulcerations on gadolinium-enhanced images (bottom right, small white arrows).
Figure 6: Imaging findings of small bowel strictures in Crohn’s disease patients. Coronal CTE image in patient with prior ileocecectomy demonstrates short segment stenosis (top left, white arrow) without imaging findings of inflammation, with subsequent endoscopy not identifying any evidence of mucosal inflammation either. Two jejunal strictures seen at CTE examination in another patient (top middle and right, white arrows) with proximal small bowel dilation (top middle and right, P) demonstrate imaging findings of inflammation with mural hyperenhancement and stratification with wall thickening. Subsequent surgical resection demonstrated stricture formation with transmural inflammation in all layers of the bowel wall. Bottom row shows images from MRE in a third patient with small bowel dilation (bottom left, P) proximal to a long segment stricture. Fast imaging employing steady-state acquisition through the stricture shows wall thickening (bottom middle, white arrows) and ulceration (bottom middle, white arrowhead), and 7-minute delayed gadolinium image shows mural stratification (bottom right, white arrows).

not reflect how inflammatory severity can vary over an inflamed bowel segment or convey adequate information regarding length and location of disease, which is needed for clinical decision-making. Further refinement of specific imaging criteria that can be readily incorporated into clinical practice for mild, moderate, and severe inflammation will be a subject for future interdisciplinary investigation.

Crohn’s disease strictures result from complex interactions between inflammatory cells, cytokines, mesenchymal cells, and enteric flora, and result in variable degrees of luminal narrowing (52). The majority of Crohn’s disease strictures have both an inflammatory and a fibrotic component due to repeated inflammation and reparative damage (53,54). Estimating the relative contribution of inflammation, fibrosis, and smooth muscle hypertrophy in dominant strictures has been an area of active imaging investigation (55,56). However, there is no universally accepted clinical or histologic scoring system for stricture-related fibrosis (52). Gastroenterologists and radiologists generally refer to different physical findings when identifying a stricture. Endoscopists generally think of luminal narrowing as a stricture. Radiologists generally rely on the presence of proximal dilation (often defined as >3 cm), as many bowel segments with Crohn’s-related inflammation demonstrate luminal narrowing, and cross-sectional imaging cannot assess luminal compliance or readily differentiate between spasm or fixed narrowing at a single time point. Moreover, both predominantly fibrotic and predominantly inflammatory strictures can fail to respond to medical therapy and ultimately require surgical intervention. Several imaging techniques and findings, such as magnetization transfer, ultrasound elastography, diffusion-weighted imaging, and relative contrast enhancement on delayed MR imaging with gadolinium, are actively being investigated for their ability to estimate fibrosis in Crohn’s disease strictures, but none of them have been fully validated. However, multiphase cinematic thick slab imaging with balanced steady-state free precession (eg, true-FISP, FIESTA, or balanced FFE) can be helpful in detecting and increasing confidence in stricture presence at MRE (57,58). Until prospective studies validating the relationship of imaging findings to histologic fibrosis are completed and a consensus emerges, Crohn’s disease strictures can be reliably identified by both luminal narrowing and unequivocal upstream dilation in order to minimize false-positive findings (Table 1) (54). Fixed luminal narrowing without upstream dilation cannot reliably be diagnosed as a stricture on a single image, but when multiple pulse sequences, fluoroscopic observation, or serial imaging examinations demonstrate fixed narrowing without upstream dilation, it is appropriate for radiologists to describe that a probable stricture is present. Enteroclysis

Radiology

Figure 6

Figure 6: Imaging findings of small bowel strictures in Crohn’s disease patients. Coronal CTE image in patient with prior ileocecectomy demonstrates short segment stenosis (top left, white arrow) without imaging findings of inflammation, with subsequent endoscopy not identifying any evidence of mucosal inflammation either. Two jejunal strictures seen at CTE examination in another patient (top middle and right, white arrows) with proximal small bowel dilation (top middle and right, P) demonstrate imaging findings of inflammation with mural hyperenhancement and stratification with wall thickening. Subsequent surgical resection demonstrated stricture formation with transmural inflammation in all layers of the bowel wall. Bottom row shows images from MRE in a third patient with small bowel dilation (bottom left, P) proximal to a long segment stricture. Fast imaging employing steady-state acquisition through the stricture shows wall thickening (bottom middle, white arrows) and ulceration (bottom middle, white arrowhead), and 7-minute delayed gadolinium image shows mural stratification (bottom right, white arrows).
Table 2

**Imaging Findings of Penetrating Disease and Mesenteric Inflammation in Crohn’s Disease**

<table>
<thead>
<tr>
<th>Imaging findings</th>
<th>Description/definition</th>
<th>Comments</th>
<th>Finding</th>
</tr>
</thead>
<tbody>
<tr>
<td>Fistulas</td>
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<tr>
<td>Simple fistula</td>
<td>Appears as an extra-enteric tract, with or without internal air or fluid (94); affected loops are often angulated or tethered</td>
<td>Fistulas should be described by bowel loop origin and structure to which they connect Usually arise from within or just proximal to a stricture (29,30) Usually arise from a stricture with active inflammation Consider postoperative leak in addition to fistulizing Crohn’s disease when examining extra-enteric tracks originating in the region of enteric anastomoses</td>
<td>13. CTE and MRE have similar and moderately high accuracy for penetrating Crohn’s disease (fistulas, inflammatory mass, abscess) (53,76,94–97). (Moderate)</td>
</tr>
<tr>
<td>Complex fistulas</td>
<td>Multiple tracts often forming an asterisk-shaped or “clover-leaf” appearance, or “star sign”; affected loops often angulated or tethered; an interloop abscess or inflammatory mass may be present</td>
<td>14. Penetrating complications detected at CTE and MRE may occur in unsuspected patients (94,98,99). (Low)</td>
<td></td>
</tr>
<tr>
<td>Sinus tract</td>
<td>Wall defect that extends outside bowel wall but not to adjacent organs or skin (usually accompanied by angulation and tethering of adjacent bowel)</td>
<td>Describe according to Parks’ or St James’ Classification (100,101), and recommend dedicated pelvic MR for assessment before surgical intervention or for activity assessment Imaging of the anus mandatory part of any CTE or MRE exam About one-quarter present at or before time of Crohn’s disease diagnosis Incidence varies by age and location of disease (102,103)</td>
<td>15. Pelvic MRI is the most accurate test for the detection and characterization of perianal Crohn’s disease, but every CTE and MRE should image the anal sphincter complex and perineum (63,104,105). (High)</td>
</tr>
<tr>
<td>Perianal fistulas</td>
<td>Arise from rectum or anus and extend to skin in perineal region or vagina</td>
<td>Associated with inflammatory stranding in mesenteric tissues. Use of the term phlegmon is discouraged</td>
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<tr>
<td>Inflammatory mass</td>
<td>Ill-defined mass-like process of mixed fat and/or soft tissue attenuation/signal intensity (not water attenuation/signal intensity) usually associated with penetrating disease, such as complex fistulas</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Abscess</td>
<td>Mesenteric/peritoneal/perianal fluid collection with rim enhancement and/or internal air</td>
<td>May be difficult to distinguish from confined leak in postoperative setting</td>
<td></td>
</tr>
<tr>
<td>Perienteric edema/inflammation</td>
<td>Increased attenuation (CT) or high T2 signal or restricted diffusion (MR) in mesenteric fat adjacent to abnormal bowel loops; if perirectal, then circumferential</td>
<td>Often associated with mesenteric border inflammation. Associated with elevated C-reactive protein (106)</td>
<td></td>
</tr>
<tr>
<td>Engorged vasa recta</td>
<td>Engorged vasa recta that supply an inflamed bowel loop (“comb sign” [44])</td>
<td>May be a marker of inflammation but may also reflect past inflammation</td>
<td></td>
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</table>

(Table 2 continues)
assessment can be helpful in equivocal cases, as it is more sensitive for stricture presence. Radiologists and clinicians should be aware that when strictures are in close proximity to each other, the ability to radiographically detect downstream small bowel strictures is compromised, as an upstream stricture is already causing an obstruction.

Following stricture identification, radiologists should state whether findings of inflammation are present or absent within the stricture (Figure 6). Findings of inflammation within a stricture are critical, as current medical treatments can alleviate inflammation and avoid or delay surgery, while true fibrotic strictures are likely to require strictureplasty, excision, or endoscopic bowel dilation. Additionally, strictures should be evaluated for symmetry, nodularity, or extension of soft tissue into the adjacent mesentery that may signal development of a neoplasm (39). Radiologists should report the number, location and length of Crohn’s disease strictures in patients so that gastroenterologists and surgeons can decide on the best therapeutic option and approach. While it is understood that the degree of bowel dilation proximal to a stricture is a result of many factors, including chronicity and ingested material, the degree of upstream dilation is often useful to endoscopists and surgeons in deciding if treatment is warranted, or which strictures to treat if multiple strictures are present. The combination of presence/absence and severity of inflammation, stricture length, and degree of upstream dilation and fistulas can provide clinicians with necessary information for treatment decisions (60).

Table 2 summarizes imaging findings in penetrating complications and mesenteric findings in Crohn’s disease. Penetrating complications result from transmural inflammation and include sinus tracts, fistulas, inflammatory masses, abscesses, and, rarely, free intraperitoneal perforation. Sinus tracts can be blind-ending in the mesentery, terminate at fascial planes, or extend longitudinally within the bowel wall. Fistulas should be described by the 2 epithelial structures they connect (eg, enteroenteric, enterocolic, enterocutaneous, rectovaginal, or enterovesical). Enteric fistulas within the abdominal cavity should be described as simple or complex similar to perianal fistulas (61). Complex, asterisk-shaped fistula complexes are often seen that tether multiple loops of small bowel and/or colon (Figure 7). Inflammatory mass describes dense mesenteric inflammation adjacent to severe mural inflammation or penetrating complications that is not an abscess and does not have a well-defined fluid component. The term phlegmon is discouraged due to its ambiguous definition, as it does not describe if there is a drainable component as in an abscess, or nondrainable, as in localized inflammation or inflammatory mass. It should be noted that clinical experience and the pathologic literature supports the strong association between stricture formation and penetrating disease (29,30). Thus, when penetrating disease is present, visual inspection should be directed at the site of fistula origin for an inflamed and stenotic bowel segment with upstream dilation, as these are nearly always present. Conversely, the proximal end of an inflamed and stenotic bowel segment should be scrutinized for detection of penetrating complications, as most arise from that part of the involved segment. We acknowledge that a weakness of the current proposal is

<table>
<thead>
<tr>
<th>Imaging findings</th>
<th>Description/definition</th>
<th>Comments</th>
<th>Finding</th>
</tr>
</thead>
<tbody>
<tr>
<td>Fibrofatty proliferation</td>
<td>Increased fat adjacent to abnormal bowel, displacing bowel loops; usually along mesenteric border, but can be circumferential</td>
<td>Also called “creeping fat”</td>
<td></td>
</tr>
<tr>
<td>Mesenteric venous thrombosis/occlusion</td>
<td>If acute, an intraluminal thrombus is seen</td>
<td>Central, acute mesenteric thromboses in PV/SMV often resolve, but peripheral mesenteric thromboses often become chronic (67)</td>
<td>Central mesenteric vein thromboses and chronic mesenteric vein occlusions can be detected at CT and MR in Crohn’s disease patients, and may be central or peripheral (68,95,107). (Low)</td>
</tr>
<tr>
<td>Adenopathy</td>
<td>Lymph node &gt; 1.5 cm in short axis</td>
<td>Reactive lymphadenopathy 1–1.5 cm in short axis diameter is considered normal in Crohn’s disease</td>
<td></td>
</tr>
</tbody>
</table>

Note.—PV, portal vein; SMV, superior mesenteric vein.

Table 2 (continued)
that some inflamed small bowel segments giving rise to fistulas will not cause proximal small bowel dilation, as the upstream pressure gradient causes decompression through the fistula rather than dilation of the proximal bowel; these segments would not be identified or termed strictures based on a strict interpretation of our proposed scheme. However, because the evidence is overwhelming when a complex fistula is seen to arise from a small bowel segment with active inflammation and no upstream dilation is present, one might consider an impression in the clinical report, such as “complex penetrating disease with active inflammatory small bowel Crohn’s disease with luminal narrowing; stricture with imaging findings of active inflammation highly likely.”

Because approximately one-quarter of Crohn’s disease patients present with an anorectal fistula, complete imaging of the anal sphincters and perineum is imperative for every CTE and MRE examination (Figure 8). Artifacts often occur over the anus due to the placement of exterior phased-array coils at MRE, but adequate anal imaging can be performed in such cases using the body coil that is intrinsic to the magnet itself. Anatomic classification, multimodality treatment, and imaging endpoints and limitations relating to perianal fistulas are outside of the focus of this work focusing on CTE and MRE in small bowel Crohn’s disease and can be found elsewhere (62); however, it should be the expectation that every CTE and MRE examination image the entire anus, and that the presence or absence of perianal disease be evaluated by the radiologist along with other imaging findings. In clinical care, gastroenterologists are often most interested in the presence or absence of a perianal fistula or abscess; detailed fistula anatomy is often not required. In
the absence of an abscess, therapy with immunosuppressive or biologic medications can proceed, whereas an abscess will require antibiotic treatment and/or drainage before the initiation or continuation of therapy, depending on its size. The question of the presence or absence of an anorectal abscess can typically be answered with CTE or MRE. Because dedicated imaging of the anus for multimodality treatment of perianal Crohn’s disease requires additional pulse sequences centered about the anus (and not included in the MRE examination), dedicated perianal MR imaging should be performed when clinically indicated as noted in a recent global consensus statement (63). Some institutions offer combined MRE and dedicated perianal examinations in patients with known small bowel and perianal disease. It should be noted that perianal disease is not considered penetrating disease in either this guideline or the Paris classification (27). The mechanism of perianal disease is distinctly different than that of classic penetrating disease (64). In addition to the anus and colorectum, radiologists should carefully inspect the appendix, as it is frequently involved with ileocolonic Crohn’s disease (65,66), and appendicitis is rarely the first presentation of Crohn’s disease. Imaging findings of appendiceal Crohn’s disease involvement are similar to those in the small bowel, and ileal-appendiceal fistulas are consequently not uncommon.

The spectrum of mesenteric vein thrombosis or occlusion has recently been described in Crohn’s disease patients (67,68). Radiologists should evaluate for and distinguish between acute mesenteric thrombosis and sequelae from prior thrombosis, sometimes referred to as chronic mesenteric vein thrombosis, but more accurately termed chronic mesenteric venous occlusion. Acute portal and superior mesenteric vein thrombus can be seen in Crohn’s disease patients as a hypoattenuating thrombus, expanding the vein. These thrombi have been observed to generally resolve without anticoagulation. However, peripheral mesenteric venous thrombi frequently evolve into chronic peripheral...
REVIEW: CT and MR Enterography in Patients With Small Bowel Crohn’s Disease

Bruining et al

Characterization of Disease Activity

Table 4 lists recommendations for clinical practice based upon the evidence for specific imaging findings. Each recommendation is accompanied by a description of the strength of the recommendation (ie, strong vs weak), with strong recommendations having anticipated desirable effects on patient outcomes (35). These recommendations set forth imaging criteria for the imaging diagnosis of Crohn’s, as well as describing its severity and complications at CTE and MRE. Furthermore, they recommend cross-sectional enterography be performed at diagnosis to detect small bowel involvement that may not be identified by other methods (Figure 10), and recommend it be considered in disease monitoring when small bowel disease or penetrating complications are present (Figure 8). The selection of CTE or MRE will vary according to a variety of factors, including patient preference, age and clinical presentation and concerns, imaging availability, and local expertise, and have been addressed, in part, in practice parameters published jointly between radiology societies (9,69). Potential factors to consider in selecting CTE or MRE as the most appropriate examination for an individual patient are listed in Table 5. MRE is generally preferred in the pediatric population, although CTE is an acceptable alternative, and some practices perform CTE at time of diagnosis. The imaging findings of Crohn’s disease at CTE and MRE are identical between pediatric and adult patients (70,71).

Table 6 lists recommended impressions in radiology reports for summarizing imaging findings and grouping them into recognized patterns of disease in a manner that is useful to referring physicians, and accounts for exacerbations and response to therapy as seen at cross-sectional enterography (Figure 1). This imaging-based morphologic construct comes from an observation of the dynamic nature of Crohn’s inflammation. As observed by Cosnes and Lemann (26,72), acute and chronic mesenteric venous thrombosis/occlusion have been correlated to increased risk for stricture or surgery in a retrospective series (68), but their impact on the natural history of disease is poorly understood.

Table 3 lists extra-intestinal findings related to Crohn’s disease (or Crohn’s disease therapies) that should be searched for in every CTE and MRE examination. The most clinically important findings are sacroiliitis, primary sclerosing cholangitis, and avascular necrosis. Many patients with Crohn’s disease complain of low back pain. Identifying the changes of sacroiliitis identifies the cause and facilitates therapy. Early primary sclerosing cholangitis is often first identified on enterography, and is manifest by the presence of discontinuous, intrahepatic bile ducts that do not connect to nondilated central ducts. Once identified, the patient can be followed more closely for complications of primary sclerosing cholangitis, typically with MR imaging/magnetic resonance cholangiopancreatography and endoscopic retrograde cholangiopancreatography. Lastly, identifying avascular necrosis will again assist in the care of a patient with hip pain and prompt avoidance of steroids when possible.

mesenteric venous occlusion on follow-up imaging, with segmental pruning of the mesenteric arcade with development of collateral pathways or small bowel varices. Chronic peripheral mesenteric venous occlusions typically correspond anatomically to small bowel segments with active or prior Crohn’s disease inflammation (Figure 9). Coronal imaging with maximum intensity projections are especially helpful in visualizing the mesenteric venous arcade. Acute and chronic mesenteric venous thrombosis/occlusion have been correlated to increased risk for stricture or surgery in a retrospective series (68), but their impact on the natural history of disease is poorly understood.

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Figure 9: Thick coronal maximum intensity projection images from CTE show typical findings of chronic mesenteric venous occlusion with narrowed peripheral mesenteric vein (top left, white arrows) and dilated peripheral marginal veins (top right and bottom left, white arrowheads) that return blood back to the portal system through collateral pathways. Note distal active small bowel inflammation (arrow, bottom right).
penetrating disease complications in a high proportion of patients, with some patients presenting with penetrating or stricturing disease complications, which may portend a more aggressive course. With mild inflammation, wall thickening and hyperenhancement is often seen without luminal narrowing. As inflammation progresses and becomes more severe, enterographic images may display increased intra-mural T2 signal, restricted diffusion, and ulcer formation in conjunction with luminal narrowing. Adoption of a consistent and well-defined reporting mechanism that links imaging findings of inflammation, stricturing disease and penetrating complications with estimates of disease severity will facilitate selection of optimal therapies and communicate disease progression and reversibility (73), and directly parallel similar linkages provided in the Lemann index without the onerous per-segment analysis required by the research tool (Appendix 2) (73).

Several terms should be used in describing the pathophysiological significance of imaging findings associated with current or prior small bowel inflammation. Active Crohn’s disease inflammation should be identified based on the predefined criteria, as should nonspecific inflammation. Active inflammation may respond to medical therapy. When no imaging findings of active inflammation are identified in patients with suspected Crohn’s disease, this should be explicitly stated in the radiologic report. Complete resolution of small bowel or colonic inflammatory findings can occur in Crohn’s disease patients, with the bowel returning to a normal appearance. In these cases, it is also correct to report that no small bowel inflammation is seen. Partial response to medical therapy may be indicated by a decrease in the severity of imaging findings within an inflamed segment, or evolution to much shorter and patchy areas of involvement over the length of the involved segment (Figure 1) (13). Alternatively, inflammation may resolve with residual findings, such as asymmetric fat deposits within the small bowel wall, residual pseudosacculation and scarring, or mild wall thickening without luminal narrowing, or other morphologic or signal changes reflecting active inflammation (ie, absent T2 signal hyperintensity, hyperenhancement, restricted diffusion). When sequelae of prior inflammation are present without active inflammation, “Crohn’s disease with no imaging signs of active inflammation is present” should be stated in the conclusion of the report. Terms such as **quiescent or chronic** are discouraged because their meaning may be erroneously interpreted, especially by patients who now, in many institutions, have access to their imaging reports. Gastroenterologists and patients making clinical decisions based on imaging findings should be aware that active vs inactive disease based on imaging criteria does not always equate to histologically, endoscopically, or clinically active or inactive disease. There is a relationship between these assessment modalities, but the properties assessed with different modalities vary.

Stricture formation occurs when there is focal or segmental luminal narrowing with unequivocal upstream dilation. Imaging findings of concomitant active inflammation are most often present (33), and we have termed this pattern **stricture with findings of active inflammation** (Figures 1 and 4). Strictures without imaging findings of inflammation may also exist. In this situation, the bowel wall is thickened without other imaging findings of inflammation. Adler et al (31) found that strictures without imaging findings of inflammation had less inflammation and less fibrosis, but lack of imaging findings of inflammation did not imply that histologic inflammation was absent. While there is a paucity of published data on the subject, in the experience of the radiologist coauthors,
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penetrating disease has not been seen to arise in the setting of a stricture without inflammation. Imaging criteria for fibrosis are currently being developed and evaluated (54,56).

Internal penetrating disease (not perianal disease) may occur at any time point during the course of the disease, but occurs overwhelmingly in patients with strictures associated with active inflammation. Sinus tract and fistula formation, abscess, and free perforation are all findings of penetrating disease. Fistulas may be simple or complex. Simple fistulas are comprised of a single tract connecting a bowel loop to adjacent bowel or other structures, such as the urinary bladder. Complex fistulas connect multiple adjacent bowel loops or structures. With both simple and complex fistulas, the bowel loops affected are often angulated and appear tethered by the fistula tract (Figure 7). Furthermore, it is common to see small, interloop abscesses along the course of these complex fistulas. If no active inflammation is associated with a fistula, this should also be stated. Postoperative fistulas are often not associated with inflammation, but obviously arise at or near the site of anastomoses.

Colonoscopy is considered the reference standard for colorectal inflammation. This guideline only addresses small bowel Crohn’s disease and complications frequently seen on CTE and MRE in these patients. A comprehensive guide for describing colorectal inflammation at cross-sectional imaging is beyond the scope of this work, as we considered CTE and MRE as part of an imaging strategy combined with clinical assessment and ileocolonoscopy. Transabdominal ultrasound (with or without intravenous contrast) and video capsule endoscopy are used at many institutions in the diagnosis and surveillance of Crohn’s disease, and their role in clinical management continues to evolve; however, integration of their imaging findings is also beyond the scope of this work, which focuses exclusively on CTE and MRE for small bowel Crohn’s disease.

Structured Reporting

Structured reporting templates are used by many radiologic practices for specific clinical scenarios to insure important clinical information is always captured in a systematic fashion. They have been shown to improve the quality of information conveyed to referring clinicians (74). Several groups have advocated for structured reporting for CTE and MRE. Table 7 demonstrates a structured cross-sectional enterography report and is adapted from Baker et al (7).

Conclusions

CTE and MRE can provide key information to guide treatment relating to the presence, severity, and extent of Crohn’s disease and its complications that is not available from clinical and endoscopic evaluation, for both adult and pediatric patients. This guideline establishes a common expectation for the use of CTE and MRE in patients with small bowel Crohn’s disease, as well as elucidating anatomic structures to be systematically evaluated, the significance of specific imaging findings, and agreed-upon terms for describing imaging findings of small bowel Crohn’s disease inflammation and its complications.

Table 4

Recommendations for Use of Computed Tomography or Magnetic Resonance Enterography, and Incorporation of Imaging Findings Into the Clinical Report

Recommendations

1. Radiologists should indicate that inflammatory small bowel Crohn’s disease is likely when either (i) in known Crohn’s patients when mural hyperenhancement and wall thickening are present, or (ii) when enteral inflammation is asymmetric or co-exists with the typical penetrating complications of Crohn’s disease. (Strong)

2. Radiologists should report the number of involved bowel segments, approximate location (proximity to ileocecal valve or ligament of Treitz), length and degree of upstream dilation of Crohn’s strictures so that gastroenterologists and surgeons can decide on the best therapeutic option and approach. (Strong)

3. When describing bowel loops having a Crohn’s stricture or penetrating disease (sinus tract, abscess or enteric fistula), radiologists should state if imaging findings of mural inflammation are present. (Strong)

4. Cross-sectional enterography should be performed at diagnosis of Crohn’s disease to detect small bowel inflammation and penetrating complications beyond the reach of standard ileocolonoscopy. (Strong)

5. Cross-sectional enterography should be considered in disease monitoring paradigms when small bowel disease or penetrating disease complications are present. (Strong)

6. Dedicated pelvic MR (perianal fistula MR imaging protocol) is required for the adequate preoperative assessment of perianal Crohn’s disease and its complications (number of fistula tracts, location and relationship to anal sphincter muscle complex, and presence of abscess), but every CTE or MRE should image the anus, and radiologists should comment if findings suspicious for perianal disease (fistula or abscess) are present. (Strong)

7. Because intramural T2 hyperintensity, restricted diffusion, peri-enteric stranding, wall thickness and mural ulcerations seen at cross-sectional enterography generally correlate with severity of endoscopic and histologic inflammation, radiologists should comment on these findings and describe them when present. (Strong)

8. MRE should be used rather than CTE, when possible, for estimating response to medical treatment in asymptomatic Crohn’s disease, as its multiparametric nature permits evaluation of multiple imaging parameters that reflect inflammation and avoids radiation. (Weak)

9. If cross-sectional enterography is indicated and intravenous contrast cannot be administered, noncontrast MRE with T2-weighted and diffusion-weighted imaging should be used an acceptable alternative. (Weak)

10. CTE and MRE exams should be carefully evaluated for evidence of mesenteric venous thromboses or occlusions and small bowel varices. (Strong)

Note.—Strong recommendation indicates confidence that the desirable effects of the test or interpretation will result in a positive impact on patient care. Weak recommendation indicates that uncertainty exists relating to the positive and negative impacts on patient care.
A shared approach for linking specific imaging findings to clinically useful impressions can be used to better guide therapeutic decision making in the short-term, and improve our understanding of the natural history of long-term complications of Crohn’s disease. As imaging techniques, new therapies, and a better understanding of the Crohn’s disease pathophysiology are developed, this shared approach can also evolve to reflect these new advances.

Acknowledgments
Members of the Society of Abdominal Radiology Crohn’s Disease-focused Panel include Mahmoud Al-Hawary (Department of Radiology, University of Michigan, Ann Arbor, Michigan), Sudha Anupindi (Department of Radiology, The Children’s Hospital of Philadelphia, Philadelphia, Pennsylvania), Mark E. Baker (Imaging Institute, Cleveland Clinic, Cleveland, Ohio),

Table 5

<table>
<thead>
<tr>
<th>Potential Considerations for Selecting Computed Tomography or Magnetic Resonance Enterography in a Crohn’s Patient</th>
<th>Consider CTE</th>
<th>Consider MRE</th>
</tr>
</thead>
<tbody>
<tr>
<td>Concern for sepsis, or suspect complex intra-abdominal penetrating disease with need for potential subsequent intervention</td>
<td>Prior CTE</td>
<td></td>
</tr>
<tr>
<td>Older patient (over 35 years old)</td>
<td>Young patient (under 35 years old)</td>
<td></td>
</tr>
<tr>
<td>First cross-sectional enterography exam or acutely symptomatic patient</td>
<td>Exam performed to evaluate Crohn’s patient that is not acutely ill or assess response to therapy</td>
<td></td>
</tr>
<tr>
<td>Test to rule out other diseases, which may cause diarrhea, or to evaluate for other small bowel diseases</td>
<td>Known perianal fistula or perianal sepsis</td>
<td></td>
</tr>
<tr>
<td>When low-dose CT techniques utilized</td>
<td>Pregnancy (performed without intravenous contrast)</td>
<td></td>
</tr>
<tr>
<td>Contraindications to MR imaging, allergy to gadolinium-based contrast media, or claustrophobia with prior MR exams</td>
<td>Iodinated contrast media allergy</td>
<td></td>
</tr>
<tr>
<td>Local imaging access and expertise</td>
<td>Local imaging access and expertise</td>
<td></td>
</tr>
</tbody>
</table>

Figure 10: CTE performed 2 weeks after normal ileocolonoscopy shows that the very distal terminal ileum (top left, black arrow) appears normal, but marked asymmetric wall thickening, comb sign, and mural stratification indicating active inflammatory Crohn’s disease is present in the more proximal terminal ileum for approximately 20 cm (top row, white arrows). On bottom row in a different patient, MRE images demonstrate extensive active small bowel inflammation as evidenced by marked wall thickening (arrows) involving long segments of jejunum and ileum, but normal-appearing terminal ileum (arrowhead). Subsequent ileoscopy and biopsy were normal.
Table 6

**Recommended Impressions Summarizing Imaging Findings of Small Bowel Crohn’s Disease at Computed Tomography and Magnetic Resonance Enterography**

<table>
<thead>
<tr>
<th>Impression</th>
<th>Imaging findings</th>
<th>Comments</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Inflammation</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Nonspecific small bowel inflammation</td>
<td>Segmental hyperenhancement and/or wall thickening in a patient without known Crohn’s disease</td>
<td>Please see segmental hyperenhancement in Table 1 for differential diagnosis</td>
</tr>
<tr>
<td>Active inflammatory small bowel Crohn’s disease</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Without luminal narrowing</td>
<td>Asymmetric wall thickening, hyperenhancement and mural edema (e, intramural T2-weighted signal) are specific for Crohn’s disease involvement</td>
<td>Describe sites, lengths, and add descriptors representing severity</td>
</tr>
<tr>
<td>With luminal narrowing</td>
<td>Ulcers, wall thickening, restricted diffusion, and perienteric stranding indicate more severe disease</td>
<td>Compare lengths and severity of disease if assessing for disease response or progression</td>
</tr>
<tr>
<td></td>
<td>Asymmetry is not required at sites of known prior disease or in a known Crohn’s disease patient</td>
<td>Severe inflammation is manifested by ulcerations, marked T2-weighted signal hyperintensity and restricted diffusion, and severe wall thickening</td>
</tr>
<tr>
<td>Crohn’s disease with no imaging signs of active inflammation (known prior active inflammatory Crohn’s disease with residual radiologic findings)</td>
<td>Imaging findings of inflammation are absent</td>
<td>Mural healing can only be described when the present study demonstrates a normal bowel segment that was inflamed on a prior exam</td>
</tr>
<tr>
<td>No imaging signs of active inflammation</td>
<td>Patchy intramural fat or residual pseudosacculation/scarring without inflammation may be seen</td>
<td></td>
</tr>
<tr>
<td><strong>Stricture</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>With imaging findings of active inflammation</td>
<td>Persistent luminal narrowing in area of Crohn’s disease with upstream dilation. Accompanying imaging findings of active inflammation Consider adding “with small bowel obstruction” if upstream dilation is moderate to severe</td>
<td>Describe location, length, degree of obstruction</td>
</tr>
<tr>
<td>Without imaging findings of active inflammation</td>
<td>Persistent segmental luminal narrowing with upstream dilation Wall thickening is present, but with absence of inflammatory findings on imaging</td>
<td></td>
</tr>
<tr>
<td>Penetrating Crohn’s disease (added in addition to determination of inflammatory Crohn’s disease and stricture)</td>
<td>Fistula and/or sinus tract; inflammatory mass; abscess; free perforation</td>
<td>Describe location and type, as well as association with Crohn’s disease stricture or inflamed bowel segment State if fistulas are simple or complex Carefully examine for asterisk-shaped fistula complexes</td>
</tr>
<tr>
<td>Perianal Crohn’s disease</td>
<td>State if perianal fistula or abscess is present or absent. If present, state if fistulas are simple or complex</td>
<td>Describe perianal disease classification, including associated abscess, with size, according to accepted criteria, if possible (63,109) Recommend consideration of pelvic MR imaging</td>
</tr>
<tr>
<td>Other complications</td>
<td>Mesenteric venous thrombosis or occlusion, AVN, PSC, sacroiliitis, pancreatitis, neoplasm, cholelithiasis, or kidney stone</td>
<td></td>
</tr>
</tbody>
</table>

**Note.**—Colonoscopy is considered the reference standard for colorectal inflammation. Recommendations for CTE and MRE descriptions of colorectal inflammation are not provided, but can parallel descriptions of small bowel inflammation, stricture, and penetration.

AVN, avascular necrosis; MRI, magnetic resonance imaging; PSC, primary sclerosing cholangitis.

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**Table 7**

**Suggested Reporting Template Adapted From Baker et al**

<table>
<thead>
<tr>
<th>MRE or CTE with intravenous contrast</th>
</tr>
</thead>
<tbody>
<tr>
<td>Appropriate entries for patient history, CT technique, oral and intravenous contrast media, other medications, and radiation dose as per institutional guidelines.</td>
</tr>
</tbody>
</table>

**Comparison:**

<table>
<thead>
<tr>
<th>Findings:</th>
</tr>
</thead>
<tbody>
<tr>
<td>Disease location (stomach, duodenum, jejunum, mid or distal ileum, terminal ileum, colon, rectum, anus)</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Number of diseased segments</th>
</tr>
</thead>
<tbody>
<tr>
<td>Type(s) of disease (if all segments have similar findings then report once; if one or more segments are different then report each separately)</td>
</tr>
</tbody>
</table>

**Inflammation**

| Describe imaging findings of inflammation (hyperenhancement, enhancement pattern, bowel wall thickening, intramural edema, ulcerations, restricted diffusion) |
| Describe location, length and severity (see Table 1), and describe stability or increase or decrease compared to prior studies |
| Other mesenteric findings (edema, mesenteric vein thrombosis, perisplenic, fibrofatty proliferation) |

**Stricture**

| State if imaging findings of inflammation is/are present |
| Describe location and length |
| Describe degree of upstream dilation (mild < 4 cm, moderate to severe > 4 cm) |

**Penetrating complications:**

| describe sinus tract, fistula, inflammatory mass, abscess, or perforation |

**Site**

**Complexity**

| Relationship to inflamed bowel or stricture |

**Perianal disease**

<table>
<thead>
<tr>
<th>Site</th>
</tr>
</thead>
<tbody>
<tr>
<td>Complexity/classification</td>
</tr>
</tbody>
</table>

**Response to therapy**

| Compare to earlier exams to describe resolution or exacerbation of inflammatory findings |

**Extra-intestinal findings:**

| Sarcoidosis, AVN, PSC, cholecystitis, nephrolithiasis, |

**Other complications or unrelated findings:**

| Chronic mesenteric vein occlusion |

**Impressions (add modifiers as shown in Table 4):**

| Inflammation statement: If inflammation is present, specify location and length, estimate severity or change |

**Nonspecific small bowel inflammation**

| Active inflammatory small bowel Crohn’s disease (± luminal narrowing) |
| Crohn’s disease with no imaging signs of active inflammation |
| No imaging signs of small bowel inflammation |

**Stricture statement**

| Stricture with signs of active inflammation, specify length of stricture and degree of proximal obstruction |
| Stricture without signs of active inflammation, specify length and degree of proximal obstruction |

**Penetrating statement:**

| describe type of fistula, simple or complex, and other penetration, and association with strictures and enteric inflammation |

**Perianal fistula (if present):**

| ± Other complications |

---

**Note:** Adapted From Baker et al (7). AVN, avascular necrosis; PSC, primary sclerosing cholangitis.

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The authors gratefully acknowledge the assistance of Dr Prakkal Deepak in literature searches to identify original research publications and meta-analyses relating to each imaging finding evaluated.
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Appendix 1. Key Technical Specifications for CT and MR Enterography

The Society of Abdominal Radiology Crohn’s Disease-Focused Panel has published key technical parameters for the performance of CTE and MRE (7.8). Both techniques utilize per oral administration of >900 mL neutral or biphasic enteric contrast agents in divided doses over 43–60 minutes before CT or MR image acquisition, followed by contrast-enhanced imaging in multiple planes to permit visualization of the small bowel wall, lumen, and peri-enteric mesentery and vascularization. Imaging of the abdomen, pelvis, and perineum (including the anal sphincter complex) is performed. Contrast-enhanced imaging is initiated during the time period between enteric and portal phases of enhancement, which is 50–70 seconds after beginning the injection of intravenous contrast. For CTE, acquisition technique is adapted to patient size with consideration for low-dose techniques, such as tube potential selection, automatic exposure control, and iterative reconstruction, with slice thickness being 2–3 mm. For MRE, T2-weighted pulse sequences, such as single-shot fast spin echo, are acquired in multiple planes, with at least 1 plane having fat saturation so that bowel wall edema can be evaluated, with additional diffusion-weighted and balanced steady-state free precession imaging being helpful. Owing to the need to ingest larger amounts of oral contrast, CTE and MRE examinations are generally outpatient imaging examinations, with individual institutions adapting these examinations for emergent settings, depending upon the patient presentation and history, and institutional personnel, scanner access, and expertise.

Appendix 2. Linkage Between Lemann Index of Digestive Disease Damage and Society for Abdominal Radiology Terms for Disease State (Impressions)

The Lemann Index or Score was developed to describe the digestive disease location, severity, extent, and progression of Crohn’s disease as measured by imaging findings and reflected in surgical resections. It is a measure of the cumulative burden of digestive disease damage. The scale is based on the following 3 aspects: strictureing lesions, penetrating lesions, and the history of surgery or any other interventional procedure. For each aspect, a grade is assigned from 0 to 3, and is summarized in Appendix Table 1.26,73

The endorsed Consensus Terms for Disease State are analogous to the Lemann index, facilitating the transfer of imaging reporting into disease damage (Appendix Table 2), the primary difference
being that the Lemann index does not necessarily state that imaging findings of inflammation are present for grade 1 or 2 strictures. For example, findings of prior inflammation, such as intramural fat, could cause wall thickening, which would be classified as grade 2 strictures using Lemann, and which would not be classified as active inflammation or strictures under the current proposal. Additionally, the current proposal creates a stronger linkage to stricture disease when present.

References

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