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American College of Radiology
ACR Appropriateness Criteria®

Clinical Condition: **Crohn's Disease**

Variant 1: **Adult; initial presentation (abdominal pain, fever, or diarrhea); Crohn's disease suspected.**

Radiologic Procedure	Rating	Comments	RRL*
CT abdomen and pelvis with contrast (CT enterography)	9		High
X-ray small-bowel follow-through	7		Med
CT abdomen and pelvis with contrast (routine)	6		High
X-ray contrast enema	6		Med
MRI abdomen and pelvis with contrast (MR enterography)	6	MR enterography may have sensitivity and specificity similar to CT enterography and avoids radiation risks. However, the choice of examination depends on institutional preferences and resources. MRI is the preferred modality for investigating perianal disease. See statement regarding contrast in text under "Anticipated Exceptions."	None
X-ray abdomen	5	May be useful to exclude free air if perforated hollow viscus is suspected.	Med
US abdomen and pelvis	5		None
US pelvis endorectal	3		None
Tc-99m HMPAO leucoscintigraphy	3		Med
Rating Scale: **1=Least appropriate, 9=Most appropriate**			***Relative Radiation Level**

Clinical Condition: **Crohn's Disease**

Variant 2: **Initial presentation of a child (less than 14 years of age); Crohn's disease suspected.**

Radiologic Procedure	Rating	Comments	RRL*
CT abdomen and pelvis with contrast (CT enterography)	9		High
MRI abdomen and pelvis with contrast (MR enterography)	9	MR enterography may have sensitivity and specificity similar to CT enterography and avoids radiation risks. However, the choice of examination depends on institutional preferences and resources. MRI is the preferred modality for investigating perianal disease. See statement regarding contrast in text under "Anticipated Exceptions."	None
CT abdomen and pelvis with contrast (routine)	8		High
X-ray small-bowel follow-through	7		High
US abdomen and pelvis	6		None
X-ray contrast enema	5		High
X-ray abdomen	5		Med
Tc-99m HMPAO leucoscintigraphy	2		Med
US pelvis endorectal	2		None
Rating Scale: 1=Least appropriate, 9=Most appropriate			*Relative Radiation Level

Variant 3: **Adult with known Crohn's disease and fever, increasing pain, leukocytosis, etc.**

Radiologic Procedure	Rating	Comments	RRL*
CT abdomen and pelvis with contrast (routine)	9		High
CT abdomen and pelvis with contrast (CT enterography)	7		High
MRI abdomen and pelvis with contrast (MR enterography)	7	MR enterography may have sensitivity and specificity similar to CT enterography and avoids radiation risks. However, the choice of examination depends on institutional preferences and resources. MRI is the preferred modality for investigating perianal disease. See statement regarding contrast in text under "Anticipated Exceptions."	None
X-ray abdomen	5	Useful for detecting free air.	Med
US abdomen and pelvis	5		None
X-ray contrast enema	5		Med
X-ray small-bowel follow-through	5		Med
US pelvis endorectal	4		None
Tc-99m HMPAO leucoscintigraphy	3		Med
Rating Scale: 1=Least appropriate, 9=Most appropriate			*Relative Radiation Level

Clinical Condition: **Crohn's Disease**

Variant 4: **Child (less than 14 years of age) with known Crohn's disease and fever, increasing pain, leukocytosis, etc.**

Radiologic Procedure	Rating	Comments	RRL*
CT abdomen and pelvis with contrast (routine)	9		High
CT abdomen and pelvis with contrast (CT enterography)	7		High
MRI abdomen and pelvis with contrast (MR enterography)	7	MR enterography may have sensitivity and specificity similar to CT enterography and avoids radiation risks. However, the choice of examination depends on institutional preferences and resources. MRI is the preferred modality for investigating perianal disease. See statement regarding contrast in text under "Anticipated Exceptions."	None
US abdomen and pelvis	6		None
X-ray abdomen	5	Useful for detection of free air.	Med
X-ray small-bowel follow-through	5		High
X-ray contrast enema	4		High
Tc-99m HMPAO leucoscintigraphy	4		Med
US pelvis endorectal	2		None
Rating Scale: 1=Least appropriate, 9=Most appropriate			*Relative Radiation Level

Clinical Condition: **Crohn's Disease**

Variant 5: **Adult with known Crohn's disease; stable, mild symptoms.**

Radiologic Procedure	Rating	Comments	RRL*
CT abdomen and pelvis with contrast (CT enterography)	9		High
MRI abdomen and pelvis with contrast (MR enterography)	8	MR enterography may have sensitivity and specificity similar to CT enterography and avoids radiation risks. Therefore, MR should be considered in patients less than 30 years old. However, the choice of examination depends on institutional preferences and resources. MRI is the preferred modality for investigating perianal disease. See statement regarding contrast in text under "Anticipated Exceptions."	None
X-ray small-bowel follow-through	7		Med
CT abdomen and pelvis with contrast (routine)	6		High
X-ray contrast enema	5		Med
X-ray abdomen	5		Med
US abdomen and pelvis	4		None
US pelvis endorectal	2		None
Tc-99m HMPAO leucoscintigraphy	2		Med
Rating Scale: 1=Least appropriate, 9=Most appropriate			*Relative Radiation Level

Clinical Condition: **Crohn's Disease**

Variant 6: **Child (less than 14 years of age) with known Crohn's disease; stable, mild symptoms.**

Radiologic Procedure	Rating	Comments	RRL*
MRI abdomen and pelvis with contrast (MR enterography)	8	MR enterography may have sensitivity and specificity similar to CT enterography and avoids radiation risks. However, the choice of examination depends on institutional preferences and resources. MRI is the preferred modality for investigating perianal disease. See statement regarding contrast in text under "Anticipated Exceptions."	None
US abdomen and pelvis	6	Very operator dependent.	None
CT abdomen and pelvis with contrast (CT enterography)	6		High
X-ray small-bowel follow-through	5		High
CT abdomen and pelvis with contrast (routine)	5		High
X-ray abdomen	5		Med
X-ray contrast enema	4		High
Tc-99m HMPAO leucoscintigraphy	2		Med
US pelvis endorectal	2		None
Rating Scale: 1=Least appropriate, 9=Most appropriate			*Relative Radiation Level

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Summary of Literature Review

Crohn's disease (CD) is a chronic inflammatory disease involving the gastrointestinal tract. The etiology is unknown, but evidence suggests that a genetic predisposition combined with an abnormal interaction between the gut and enteric microorganisms may play a role in the pathogenesis. Patients usually present with the abrupt or insidious onset of abdominal pain and diarrhea, frequently accompanied by fever and weight loss. The small intestine and colon are most commonly affected, but any portion of the bowel from mouth to anus may be involved. The small-bowel is affected alone in about a third of patients, the colon alone in 20%-30% of patients, and combined involvement of the colon and the small-bowel is seen in 40%-50% of patients. The severity of symptoms, frequency of complications, and likelihood of intestinal resection due to CD are typically greater in patients with ileocolic involvement than in those with disease limited to the small-bowel or colon alone [1].

Characteristic pathologic findings of CD in the gut include transmural granulomatous inflammation; deep ulcers that may progress to sinus tracts and fistulae; strictures that may lead to intestinal obstruction; and discontinuous involvement, with skip areas between diseased segments. Extraintestinal manifestations are common and include arthritis, cholelithiasis, ocular manifestations, dermatologic abnormalities, and, in children, growth retardation [2].

Role of Radiology

The initial diagnosis of CD is based on a combination of clinical, laboratory, histological, and imaging findings. No single diagnostic test allows unequivocal diagnosis. The imaging characteristics and distribution of disease provide supportive evidence for the diagnosis of CD. Imaging is commonly called upon to distinguish CD from other conditions causing colitis. In particular, the presence of small-bowel involvement helps distinguish CD from ulcerative colitis.

In the last decade many new therapeutic strategies have been developed that have allowed the gastroenterologist and surgeon to treat virtually all forms of CD effectively [3]. The success of these treatments (which target specific subtypes of CD) depends on accurate diagnosis of the nature and extent of disease. Therefore, it is no longer sufficient for the radiologist to only detect the presence of CD—he or she must also accurately assess its subtype, location, and severity. This is particularly important in distinguishing segmental small-bowel narrowing due to active disease (which is effectively treated with medical therapy) from fibrotic strictures (more amenable to stricturoplasty). Likewise, complex fistulas may be more effectively treated surgically, while simple fistulas usually respond to agents like infliximab that inhibit tumor necrosis factor (TNF). Therefore, accurate delineation of the frequently complex anatomy of these lesions is essential.

Radiology has traditionally played a smaller role in the long-term surveillance of patients with known CD because there is a poor correlation between clinical disease activity and the radiographic changes on barium studies [4]. New imaging techniques discussed in the following sections hold promise in predicting disease activity. It is well recognized that imaging is important in the evaluation of patients with complications of the disease, such as bowel obstruction, fistula formation, and abscess. This narrative will discuss the role of various imaging modalities in the initial diagnosis of CD and in the management of suspected complications of the disease.

Initial Presentation

Radiographs of the Abdomen

Radiographs often depict abnormalities in patients with inflammatory bowel disease (IBD), and some authors [5] advocate their routine use. Findings include mural thickening and dilatation; mucosal abnormalities of the small-bowel and colon; and abnormal distribution of feces, with areas of colonic involvement devoid of fecal material. However, a false positive rate of 16%-20% and the low positive predictive value of a normal radiograph (62%) make radiography a poor screening test in patients at initial presentation: negative findings cannot preclude further studies, and positive findings would also lead to other radiological procedures to more accurately characterize the type of IBD and to map its anatomic distribution in the gut. For these reasons, radiographs are not essential when the initial presentation is typical for IBD and the disease is not severe. If a bowel perforation

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is suspected, abdominal radiographs may be useful for evaluation of free air.

Barium Studies of the Gastrointestinal Tract
Barium studies of the small-bowel have traditionally been the primary imaging methods of choice in the diagnosis of CD. However, new techniques have been shown to offer improved sensitivity and are replacing barium studies as the preferred diagnostic tests [6-8]. The recent introduction of wireless capsule endoscopy is likely to play an increasing role in early diagnosis of CD [9]. However, because of a 5% incidence of capsule retention proximal to unsuspected strictures, imaging studies, such as small-bowel follow-through (SBFT), are likely to remain an important screening tool prior to capsule endoscopy examinations.

The small-bowel can be evaluated by either SBFT or enteroclysis, and each has its proponents [10-13]. Both techniques are quite accurate in detecting small-bowel involvement when performed correctly (89%-97% for conventional SBFT and 83%-100% for enteroclysis [1]), through the superior diagnostic accuracy of enteroclysis in other conditions (eg, detecting small-bowel neoplasms and Meckel's diverticula) is not as well established in the evaluation of IBD. While enteroclysis has a shorter overall examination time, the peroral SBFT requires less total room time and radiologist time and substantially less radiation exposure. It also has fewer side effects and greater patient acceptance. For these reasons, detailed SBFT, with frequent fluoroscopy using graded compression, is the best means of evaluating the small-bowel, particularly in younger patients. Enteroclysis is usually reserved for problematic cases.

The peroral pneumocolon examination is a useful adjunct to SBFT or enteroclysis. Once the terminal ileum has been opacified, air is instilled through the rectum to obtain a double-contrast examination of the distal small-bowel (or the ascending colon, or both). Often this technique will result in better distension of the terminal ileum and provide better mucosal detail [14].

Endoscopy is the preferred initial examination of the colon in patients suspected of having IBD. It is superior to the barium enema in detecting early changes and has largely replaced it as the initial diagnostic examination. The barium enema is reserved for those patients with unsuccessful colonoscopy or with contraindications such as patients on anticoagulation therapy.

Ultrasound
Numerous ultrasound (US) studies have documented the ability of transabdominal US to demonstrate the presence of CD. US findings of CD include bowel wall thickening (≥4-5 mm), producing the target sign when seen in cross-section, and reduced or absent peristalsis in affected loops.

More recently, proponents have argued that US could replace SBFT in the initial evaluation of patients suspected to have CD [15] or in the surveillance of patients (particularly children) with CD [16], because of its acceptable sensitivity and the lack of radiation exposure. In the one prospective comparison of US and barium studies [15], which used the barium study as the gold standard, in the initial evaluation of suspected CD, the sensitivity of US was 75% and the specificity was 97%. The authors describe a steep learning curve, with sensitivity increasing to 87% as experience is gained. This finding emphasizes the frequently made point that US is quite operator-dependent, perhaps more so than other modalities. Recent introduction of US contrast agents and power Doppler techniques suggest an increasing role for these techniques in the future [17,18]. These data point to a potential role for US as the initial modality in patients (especially children) suspected of having CD.

Nuclear Medicine
Nuclear medicine plays little role in the initial evaluation of patients suspected of having CD. Radionuclide studies are not as effective as endoscopy or other imaging studies in assessing disease extent, and they lack the anatomic detail provided by other studies.

Computed Tomography
Although computed tomography (CT) has traditionally been used to evaluate extraenteric complications of CD such as bowel obstruction, abscess, and fistula, multidetector CT has shown considerable promise in initial diagnosis and estimation of disease severity [19-22]. Two modifications of standard abdominal CT technique are especially promising. These techniques differ from standard abdominal CT by using intraluminal bowel distension with neutral enteric contrast, multidetector CT with narrow slice thickness and reconstruction interval, and IV contrast administration followed by scan delays that optimize bowel wall enhancement. Large volumes of enteric contrast are necessary to achieve adequate luminal distension and may be administered orally (CT enterography) [23] or injected through a nasojejunal tube (CT enteroclysis) [24]. The peroral administration of contrast enjoys greater patient acceptance and results in acceptable degrees of luminal distension [25]. The use of neutral rather than positive enteric contrast is important so as not to obscure mucosal enhancement—an important indicator of active disease. Active disease is identified by mucosal hyperenhancement, bowel wall thickening, mural stratification, and hyperemic vasa recta [20,22,23,26,27]. There is growing evidence that CT is more sensitivity than barium examinations in detecting CD [7,8,21,22,25,28-31]. Unlike conventional barium studies, CT allows good visualization of pelvic small-bowel loops that are often obscured due to overlapping bowel in barium studies. CT also competes favorably with conventional and capsule endoscopy [30].

Magnetic Resonance Imaging
Contrast-enhanced magnetic resonance imaging (MRI) scanning using fast imaging techniques, combined with enterography and enteroclysis techniques to optimize bowel distension, can accurately display bowel wall changes in early CD [32-36]. MRI appears similar to CT enterography/enteroclysis and superior to barium small-

bowel studies in diagnosing and depicting disease extent [6,32,37-39]. Characteristic bowel wall changes such as mural hyperenhancement, bowel wall thickening, mural stratification, and hyperemic vasa recta are similar to these seen with CT. MRI's ability to visualize these changes without the risks associated with ionizing radiation makes it a desirable technique for examining CD in children and in patients who must be subjected to multiple serial examinations [6,40,41] and will likely result in increased use of these techniques in the future.

Both CT and MRI offer promise in evaluating disease activity and can be used to evaluate response to therapy [34,42-47]. The high cost and associated risks of treatment with anti-TNF agents makes accurate assessment of response to therapy imperative.

Patients with Known Crohn's Disease Presenting with Acute Exacerbation or Symptoms, or with Suspected Complications

CD is a chronic disease, with frequent relapses and superimposed complications. These include bowel obstruction due to strictures; intra-abdominal or pelvic abscess; development of fistulae to skin, bladder, vagina, etc.; and toxic megacolon in patients with colonic CD.

Radiographs of the Abdomen

In patients with fulminant symptoms, radiographs are useful, because they can often detect the presence of bowel obstruction, perforation, or toxic colon distention, directing further treatment quickly.

Barium Studies of the Gastrointestinal Tract

Barium small-bowel examinations remain useful in evaluating suspected complications of CD. The presence and anatomy of strictures and fistulas assist in preoperative planning. In patients who are acutely ill, with peritoneal signs or acute diarrhea, barium studies are not indicated because of the risk of perforation.

For evaluating the colon in patients with acute exacerbations, colonoscopy has supplanted barium enema. In patients with a low-risk of perforation, a carefully performed barium enema can still provide valuable information, especially if fistula or stenoses are suspected.

In patients with CD who present with pain, a palpable mass, or fever and in whom an abscess is suspected, barium studies have little role. While they may demonstrate a fistulous communication with an abscess, a negative study does not preclude other studies, and a positive one will likewise lead to additional imaging to guide therapy, such as percutaneous drainage.

Ultrasound

US has a limited role in management of suspected complications of CD except in children and in patients with perianal fistulas. The risks associated with ionizing radiation favor the role of US and MRI in evaluating pediatric CD patients who are likely to require multiple examinations over the course of their disease.

Endoscopic US has been shown to be superior to CT and conventional fistulography and plays a complementary role with MRI [32,48] in evaluation of Crohn's sperianal fistulas. Its ability to depict perianal anatomy makes it a valuable tool for preoperative planning.

Nuclear Medicine

Numerous articles [49-53] support the use of technetium hexamethyl propylene amine oxime (HMPAO)-labeled white blood cells, with single proton emission computed tomography (SPECT) imaging, in assessing disease activity. These advocates propose that, once the histological diagnosis of CD has been established, the disease activity can be reliably assessed by this technique. Its advantages over barium studies include the examination of both large and small-bowel in one encounter, lower radiation exposure (important in younger patients, especially children, who will have multiple studies over their lifetime), and higher patient acceptance [51]. In addition, technetium HMPAO-labeled leucoscintigraphy can accurately distinguish CD from ulcerative colitis in a large proportion of patients, and may actually exceed conventional radiology in this regard [51]. Recent application of SPECT leucoscintigraphy [50] and positron emission tomography (PET) [54] has reduced the false positive rate from physiological uptake in adjacent organs; however, the specificity remains limited.

While some advocates of leucoscintigraphy have argued that this technique compares favorably with CT and US in diagnosing extraintestinal complications of CD, this view is not widely accepted, and nuclear medicine plays a subordinate role in patients with known CD who present with signs and symptoms of abscess, fistula formation, or bowel obstruction.

Computed Tomography

Currently, CT is the initial imaging technique of choice in suspected CD complications for both adults [55] and children [56]. In one large study of 80 patients [57], CT detected unsuspected findings that led to a change of medical or surgical management in 28% of patients. CT can most often differentiate the various causes of palpable abdominal mass (fibrofatty proliferation, abscess, thickened bowel wall, phlegmon, or neoplasm), and often can depict fistulas and sinus tracts.

Magnetic Resonance Imaging

Improvements in MRI technology, such as fast scanning techniques, have permitted accurate diagnosis of complications of CD, including abscess, fistula, and stenosis [45,47,48]. MRI is useful when ionizing radiation is contraindicated, and it has been used successfully in children and pregnant women. Along with endoscopic US, MRI is the preferred tool for evaluating perianal complications of CD.

Angiography and Interventional Radiology

The primary role of interventional radiology is in the percutaneous drainage of abscesses complicating CD. Numerous studies have documented the effective use of

this technique, which is now the procedure of choice, often obviating the need for surgical resection [58,59].

Anticipated Exceptions

Nephrogenic systemic fibrosis (NSF) is a disorder with a scleroderma-like presentation and a spectrum of manifestations that can range from limited clinical sequelae to fatality. It appears to be related to both underlying severe renal dysfunction and the administration of gadolinium-based contrast agents. It has occurred primarily in patients on dialysis, rarely in patients with very limited glomerular filtration rate (GFR) (ie, <30 mL/min/1.73m^2), and almost never in other patients. There is growing literature regarding NSF. Although some controversy and lack of clarity remain, there is a consensus that it is advisable to avoid all gadolinium-based contrast agents in dialysis-dependent patients unless the possible benefits clearly outweigh the risk, and to limit the type and amount in patients with estimated GFR rates <30 mL/min/1.73m^2. For more information, please see the ACR *Manual on Contrast Media* [60].

Relative Radiation Level Information

Potential adverse health effects associated with radiation exposure are an important factor to consider when selecting the appropriate imaging procedure. Because there is a wide range of radiation exposures associated with different diagnostic procedures, a relative radiation level (RRL) indication has been included for each imaging examination. The RRLs are based on effective dose, which is a radiation dose quantity that is used to estimate population total radiation risk associated with an imaging procedure. Additional information regarding radiation dose assessment for imaging examinations can be found in the ACR Appropriateness Criteria® Radiation Dose Assessment Introduction document.

Relative Radiation Level Designations	
Relative Radiation Level	**Effective Dose Estimate Range**
None	0
Minimal	< 0.1 mSv
Low	0.1-1 mSv
Medium	1-10 mSv
High	10-100 mSv

Supporting Document(s)

- ACR Appropriateness Criteria® Overview
- Evidence Table

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