

**American College of Radiology
ACR Appropriateness Criteria®**

Clinical Condition: Crohn Disease

Variant 1: Adult. Initial presentation. Suspected Crohn disease.

Radiologic Procedure	Rating	Comments	<u>RRL*</u>
CT abdomen and pelvis with contrast (CT enterography)	9		☼ ☼ ☼ ☼
MRI abdomen and pelvis without and 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."	O
X-ray small-bowel follow-through	7		☼ ☼ ☼
CT abdomen and pelvis with contrast (routine)	6		☼ ☼ ☼ ☼
X-ray contrast enema	6		☼ ☼ ☼
X-ray abdomen	5	May be useful to exclude free air if perforated hollow viscus is suspected.	☼ ☼ ☼
US abdomen and pelvis	5		O
US pelvis endorectal	3		O
Tc-99m HMPAO leucoscintigraphy	3		☼ ☼ ☼
Rating Scale: 1,2,3 Usually not appropriate; 4,5,6 May be appropriate; 7,8,9 Usually appropriate			*Relative Radiation Level

Clinical Condition:**Crohn Disease****Variant 2:****Child or young adult. Initial presentation. Suspected Crohn disease.**

Radiologic Procedure	Rating	Comments	<u>RRL*</u>
CT abdomen and pelvis with contrast (CT enterography)	9		☼☼☼☼
MRI abdomen and pelvis without and 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.”	O
CT abdomen and pelvis with contrast (routine)	7		☼☼☼☼
X-ray small-bowel follow-through	7	The RRL for the adult procedure is ☼☼☼☼.	☼☼☼☼
US abdomen and pelvis	6		O
X-ray contrast enema	5	The RRL for the adult procedure is ☼☼☼☼.	☼☼☼☼
X-ray abdomen	5	May be useful to exclude free air if perforated hollow viscus is suspected.	☼☼☼
Tc-99m HMPAO leucoscintigraphy	3		☼☼☼
US pelvis endorectal	2		O
Rating Scale: 1,2,3 Usually not appropriate; 4,5,6 May be appropriate; 7,8,9 Usually appropriate			*Relative Radiation Level

Clinical Condition:**Crohn Disease****Variant 3:****Adult with known Crohn disease; acute exacerbation such as fever or increasing abdominal pain or leukocytosis.**

Radiologic Procedure	Rating	Comments	<u>RRL*</u>
CT abdomen and pelvis with contrast (routine)	9	Routine CT may be acceptable to detect abscess or bowel obstruction if patient is unable to drink the volume of contrast required for enterography.	☼ ☼ ☼ ☼
CT abdomen and pelvis with contrast (CT enterography)	9		☼ ☼ ☼ ☼
MRI abdomen and pelvis without and 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.”	O
X-ray abdomen	5	May be useful to exclude free air if perforated hollow viscus is suspected.	☼ ☼ ☼
US abdomen and pelvis	5		O
X-ray contrast enema	4		☼ ☼ ☼
X-ray small-bowel follow-through	4		☼ ☼ ☼
US pelvis endorectal	4		O
Tc-99m HMPAO leucoscintigraphy	4		☼ ☼ ☼
Rating Scale: 1,2,3 Usually not appropriate; 4,5,6 May be appropriate; 7,8,9 Usually appropriate			*Relative Radiation Level

Clinical Condition:**Crohn Disease****Variant 4:****Child or young adult with known Crohn disease; acute exacerbation such as fever or increasing abdominal pain or leukocytosis.**

Radiologic Procedure	Rating	Comments	<u>RRL*</u>
CT abdomen and pelvis with contrast (routine)	9	Routine CT may be acceptable to detect abscess or bowel obstruction if patient is unable to drink the volume of contrast required for enterography.	☼ ☼ ☼ ☼
CT abdomen and pelvis with contrast (CT enterography)	9	Consider dose reduction techniques.	☼ ☼ ☼ ☼
MRI abdomen and pelvis without and 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.”	O
US abdomen and pelvis	6		O
X-ray abdomen	5	May be useful to exclude free air if perforated hollow viscus is suspected.	☼ ☼ ☼
X-ray small-bowel follow-through	5	The RRL for the adult procedure is ☼ ☼ ☼ .	☼ ☼ ☼ ☼
X-ray contrast enema	4	The RRL for the adult procedure is ☼ ☼ ☼ .	☼ ☼ ☼ ☼
Tc-99m HMPAO leucoscintigraphy	4		☼ ☼ ☼
US pelvis endorectal	2		O
<u>Rating Scale:</u> 1,2,3 Usually not appropriate; 4,5,6 May be appropriate; 7,8,9 Usually appropriate			*Relative Radiation Level

Clinical Condition:**Crohn Disease****Variant 5:****Adult with known Crohn disease; stable, mild symptoms and/or surveillance.**

Radiologic Procedure	Rating	Comments	<u>RRL*</u>
CT abdomen and pelvis with contrast (CT enterography)	9	Consider dose reduction techniques.	☼ ☼ ☼ ☼
MRI abdomen and pelvis without and 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.”	O
X-ray small-bowel follow-through	7		☼ ☼ ☼
CT abdomen and pelvis with contrast (routine)	6		☼ ☼ ☼ ☼
X-ray abdomen	5	May be useful to exclude free air if perforated hollow viscus is suspected.	☼ ☼ ☼
X-ray contrast enema	4		☼ ☼ ☼
US abdomen and pelvis	4		O
US pelvis endorectal	2		O
Tc-99m HMPAO leucoscintigraphy	2		☼ ☼ ☼
Rating Scale: 1,2,3 Usually not appropriate; 4,5,6 May be appropriate; 7,8,9 Usually appropriate			*Relative Radiation Level

Clinical Condition:**Crohn Disease****Variant 6:****Child or young adult with known Crohn disease; stable, mild symptoms and/or surveillance.**

Radiologic Procedure	Rating	Comments	<u>RRL*</u>
MRI abdomen and pelvis without and 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."	O
US abdomen and pelvis	6		O
CT abdomen and pelvis with contrast (CT enterography)	6	Consider dose reduction techniques. The higher spatial resolution obtained with CT is usually not required for surveillance of areas of known Crohn disease.	☼☼☼☼
X-ray small-bowel follow-through	5	The RRL for the adult procedure is ☼☼☼.	☼☼☼☼
CT abdomen and pelvis with contrast (routine)	5		☼☼☼☼
X-ray abdomen	5	May be useful to exclude free air if perforated hollow viscus is suspected.	☼☼☼
X-ray contrast enema	4	The RRL for the adult procedure is ☼☼☼.	☼☼☼☼
Tc-99m HMPAO leucoscintigraphy	2		☼☼☼
US pelvis endorectal	2		O
<u>Rating Scale:</u> 1,2,3 Usually not appropriate; 4,5,6 May be appropriate; 7,8,9 Usually appropriate			*Relative Radiation Level

CROHN DISEASE

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Summary of Literature Review

Introduction

Crohn disease (CD) is a chronic inflammatory disease involving the gastrointestinal tract and is increasing in prevalence [1]. 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 [2].

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 [3].

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 [4]. 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 [5]. New imaging techniques discussed in the following sections hold promise in diagnosis, predicting disease activity, and monitoring therapy. 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 [6] 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

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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 is suspected, abdominal radiographs may be useful for evaluating 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 [7-9]. The relatively recent introduction of wireless capsule endoscopy is likely to play an increasing role in early diagnosis of CD [10]. 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 [11-14]. Both techniques are quite accurate in detecting small-bowel involvement when performed correctly (89%-97% for conventional SBFT and 83%-100% for enteroclysis [2]), though 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 [15].

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 [16-22]. 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.

Proponents argue that US could replace SBFT in the initial evaluation of patients suspected to have CD [21] or in the surveillance of patients (particularly children) with CD [16-20,22], because of its acceptable sensitivity and the lack of radiation exposure. In the one prospective comparison of US and barium studies [21], which used the barium study as the reference 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. Recent introduction of US contrast agents and power Doppler techniques suggest an increasing role for these techniques in the future [23-30]. These data point to a potential role for US as the initial modality in patients (especially children) suspected of having CD.

Nuclear Medicine

At many places nuclear medicine currently plays little role in the initial evaluation of patients suspected of having CD. However, when it is compared to endoscopy and biopsy, some prospective studies have suggested that Tc-99m white blood cell (WBC) imaging is superior to contrast radiology for assessing the extent and activity of inflammatory bowel disease [31-37]. The Tc-99m WBC scan seems ideally suited to obtain, in only one examination, a precise temporal snapshot of the distribution and intensity of inflammation. The test may be useful in patients with inconspicuous signs suggesting IBD and in whom laboratory test results are either normal or slightly abnormal. In those cases, a negative Tc-99m WBC study may obviate endoscopic investigations.

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 [38-42]. 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) [43] or injected through a nasojejunal tube (CT enteroclysis) [44]. The peroral administration of contrast enjoys greater patient acceptance and results in acceptable degrees of luminal distension [45-46]. 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 bowel wall thickening with mural hyperenhancement occurring in a stratified enhancement pattern and hyperemic vasa recta [39,41,43,47-51]. In more severe inflammation perienteric inflammatory changes are seen. There is growing

evidence that CT is more sensitive than barium examinations in detecting CD [8-9,40-41,45,52-55]. Unlike conventional barium studies, CT allows good visualization of pelvic small-bowel loops that are often obscured due to overlapping bowel in barium studies for the detection of CD. CT also competes favorably with conventional and capsule endoscopy [54]. Dose reduction techniques are becoming more widely available and offer the potential to decrease radiation exposure considerably. These techniques may be an alternative when imaging of the bowel is desired to monitor therapy [56-58].

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 [59-63]. MRI appears similar to CT enterography/enteroclysis and superior to barium small-bowel studies for the diagnosis and depiction of disease extent [7,59,64-68]. Characteristic bowel wall changes suggesting active inflammation include bowel wall thickening, high T2 mural signal, mural hyperenhancement with mural stratification, and hyperemic vasa recta [18,69-76]. MRI's ability to reveal these changes without the risks associated with ionizing radiation makes it a desirable technique for examining CD in children and in patients who may or must be subjected to multiple serial examinations [7,77-80] 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 [61,81-88]. The high cost and associated risks of treatment with anti-TNF agents and the poor correlation of disease activity with clinical symptoms make accurate assessment of response to therapy imperative [88].

The colon can be evaluated by both CT and MRI provided there is adequate distension, which can be accomplished with antegrade filling by oral contrast or rectal administration of fluid [89-90]. The sensitivity for detecting active disease in the colon with cross-sectional imaging has been reported to be inferior to that of colonoscopy [91-92]. Routine CT colonography (CTC) techniques are not usually indicated for the detection of CD, as IV contrast is not usually administered and the blind administration of room air or carbon dioxide for colonic distension can be a contraindication in a severely inflamed colon (toxic megacolon). In addition, colonic cleansing, which is required for CTC, is not usually required for detecting inflammation by enterography or enteroclysis technique. CTC may be useful to screen for colorectal cancer proximal to fibrostenotic strictures in the colon.

Patients with Known Crohn 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 [59,93-94] in evaluation of Crohn's perianal fistulas. Its ability to depict perianal anatomy makes it a valuable tool for preoperative planning.

Nuclear Medicine

Numerous articles [95-99] support the use of technetium hexamethyl propylene amine oxime (HMPAO)-labeled white blood cells, with single photon 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 [97]. When compared to endoscopy and biopsy, some prospective studies have suggested that Tc-99m white blood cell (WBC) imaging is superior to contrast radiology for assessing the extent and activity of inflammatory bowel disease. It is economical compared

with endoscopy, and its diagnostic sensitivity is excellent [31-37]. In addition, technetium HMPAO-labeled leucoscintigraphy can be used to accurately distinguish CD from ulcerative colitis in a large proportion of patients, and it may actually exceed conventional radiology in this regard [97]. Recent application of SPECT leucoscintigraphy [96] and positron emission tomography (PET) [100] 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.

Flourine-18-2-fluoro-2-deoxy-D-glucose (FDG) tracer is taken up in areas of active inflammation and when used with CT (PET/CT), allows improved localization. However, poor bowel distension can lead to false positive examinations. More recently PET/CT has been combined with CT enterography or enteroclysis techniques to further improve localization and reduce false positives. Preliminary studies have shown that the correlation of FDG with CT enterography or enteroclysis may help with the differentiation of predominant active or fibrotic strictures and aid in developing management algorithms [101-104]. Limitations include the radiation dose and the cost of the procedure. Further studies are needed to determine the role of this technique in CD before it can be more highly recommended.

Computed Tomography

Currently, CT [105] or CT enterography [106-107] is the initial imaging technique of choice in suspected CD complications for both adults and children [108]. Studies have shown that CT-demonstrated unsuspected findings led to a change of medical or surgical management in 28% of patients [109]. In one study, penetrating disease was seen in 20.7% of patients referred for CT enterography, which was a new finding in 58.1% [110]. In another study, in approximately 50% of patients who had penetrating disease identified on CT enterography, there was no clinical suspicion of fistula or abscess [106]. CT can most often be used to 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 [84,86,93,111]. 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 [112-113].

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 [114-116].

Summary

- Cross-sectional (CT and MR) enterography are the preferred imaging tests for the initial diagnosis and surveillance of patients with suspected and known Crohn disease.
- High-quality MR enterography provides the opportunity to eliminate radiation exposure for children and young adults while maintaining similar sensitivity to that of CT enterography. Institutional preference will be determined by availability, experience, and expertise.
- Barium studies (small-bowel series and barium enema) are being used less frequently in the imaging of Crohn disease but may be extremely helpful in demonstrating anatomy and strictures for preoperative planning purposes.
- Nuclear medicine techniques may be helpful in certain scenarios but are not widely used. Utilization will be determined by institutional preference.

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/1.73m²), 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/1.73m². For more information, please see the [ACR Manual on Contrast Media](#) [117].

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. Patients in the pediatric age group are at inherently higher risk from exposure, both because of organ sensitivity and longer life expectancy (relevant to

the long latency that appears to accompany radiation exposure). For these reasons, the RRL dose estimate ranges for pediatric examinations are lower as compared to those specified for adults (see Table below). 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*	Adult Effective Dose Estimate Range	Pediatric Effective Dose Estimate Range
O	0 mSv	0 mSv
☼	<0.1 mSv	<0.03 mSv
☼ ☼	0.1-1 mSv	0.03-0.3 mSv
☼ ☼ ☼	1-10 mSv	0.3- 3 mSv
☼ ☼ ☼ ☼	10-30 mSv	3-10 mSv
☼ ☼ ☼ ☼ ☼	30-100 mSv	10-30 mSv

*RRL assignments for some of the examinations cannot be made, because the actual patient doses in these procedures vary as a function of a number of factors (eg, region of the body exposed to ionizing radiation, the imaging guidance that is used). The RRLs for these examinations are designated as NS (not specified).

Supporting Document(s)

- [ACR Appropriateness Criteria® Overview](#)
- [Procedure Information](#)
- [Evidence Table](#)

References

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The ACR Committee on Appropriateness Criteria and its expert panels have developed criteria for determining appropriate imaging examinations for diagnosis and treatment of specified medical condition(s). These criteria are intended to guide radiologists, radiation oncologists and referring physicians in making decisions regarding radiologic imaging and treatment. Generally, the complexity and severity of a patient's clinical condition should dictate the selection of appropriate imaging procedures or treatments. Only those examinations generally used for evaluation of the patient's condition are ranked. Other imaging studies necessary to evaluate other co-existent diseases or other medical consequences of this condition are not considered in this document. The availability of equipment or personnel may influence the selection of appropriate imaging procedures or treatments. Imaging techniques classified as investigational by the FDA have not been considered in developing these criteria; however, study of new equipment and applications should be encouraged. The ultimate decision regarding the appropriateness of any specific radiologic examination or treatment must be made by the referring physician and radiologist in light of all the circumstances presented in an individual examination.