ACR–SAR–SPR PRACTICE PARAMETER FOR THE PERFORMANCE OF COMPUTED TOMOGRAPHY (CT) ENTEROGRAPHY

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PREAMBLE

This document is an educational tool designed to assist practitioners in providing appropriate radiologic care for patients. Practice Parameters and Technical Standards are not inflexible rules or requirements of practice and are not intended, nor should they be used, to establish a legal standard of care[1]. For these reasons and those set forth below, the American College of Radiology and our collaborating medical specialty societies caution against the use of these documents in litigation in which the clinical decisions of a practitioner are called into question.

The ultimate judgment regarding the propriety of any specific procedure or course of action must be made by the practitioner considering all the circumstances presented. Thus, an approach that differs from the guidance in this document, standing alone, does not necessarily imply that the approach was below the standard of care. To the contrary, a conscientious practitioner may responsibly adopt a course of action different from that set forth in this document when, in the reasonable judgment of the practitioner, such course of action is indicated by variables such as the condition of the patient, limitations of available resources, or advances in knowledge or technology after publication of this document. However, a practitioner who employs an approach substantially different from the guidance in this document may consider documenting in the patient record information sufficient to explain the approach taken.

The practice of medicine involves the science, and the art of dealing with the prevention, diagnosis, alleviation, and treatment of disease. The variety and complexity of human conditions make it impossible to always reach the most appropriate diagnosis or to predict with certainty a particular response to treatment. Therefore, it should be recognized that adherence to the guidance in this document will not assure an accurate diagnosis or a successful outcome. All that should be expected is that the practitioner will follow a reasonable course of action based on current knowledge, available resources, and the needs of the patient to deliver effective and safe medical care. The purpose of this document is to assist practitioners in achieving this objective.

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1 *Iowa Medical Society and Iowa Society of Anesthesiologists v. Iowa Board of Nursing, 831 N.W.2d 826 (Iowa 2013) Iowa Supreme Court refuses to find that the "ACR Technical Standard for Management of the Use of Radiation in Fluoroscopic Procedures (Revised 2008)" sets a national standard for who may perform fluoroscopic procedures in light of the standard's stated purpose that ACR standards are educational tools and not intended to establish a legal standard of care. See also, Stanley v. McCarver, 63 P.3d 1076 (Ariz. App. 2003) where in a concurring opinion the Court stated that "published standards or guidelines of specialty medical organizations are useful in determining the duty owed or the standard of care applicable in a given situation" even though ACR standards themselves do not establish the standard of care.*

I. INTRODUCTION

This practice parameter was revised collaboratively by the American College of Radiology (ACR), Society for Pediatric Radiology (SPR), and the Society of Abdominal Radiology (SAR).

CT enterography (CTE) is an examination using neutral oral contrast agents (with density of <20-30 HU) and intravenous (IV) contrast medium, with multidetector CT (MDCT) in the evaluation of small-bowel diseases [1-20]. In most centers caring for patients with Crohn's disease , CT and MR enterography (MRE) have become the standard of care and have supplanted traditional barium-based fluoroscopic techniques (small-bowel series and enteroclysis) [21] (see the ACR–SAR–SPR Practice Parameter for the Performance of Magnetic Resonance (MR) Enterography [22]).

II. INDICATIONS AND CONTRAINDICATIONS

Clinical indications and contraindications for CTE include, but are not limited to, the following:

A. Indications
   1. Known inflammatory bowel disease not in the perioperative period
   2. Suspected Crohn's disease or other causes of small-bowel inflammation
   3. Suspected small-bowel bleeding (formally obscure gastrointestinal bleeding). This study should be performed if upper and lower endoscopy fail to identify bleeding Note: Suspected acute as well as small-bowel bleeding should be evaluated with multiphasic technique and not uniphasic CTE.
   4. Suspected small-bowel disease (eg, celiac disease)
   5. Chronic diarrhea and/or abdominal pain
   6. Suspected chronic mesenteric ischemia

B. Contraindications (most are relative) when Other Examinations may be more Efficacious
   1. Patients with a known, severe iodinated contrast media allergy who are able to undergo MRE
   2. Patients with chronic kidney disease whose estimated glomerular filtration rate (eGFR) is < 30 mL/min/1.73 m^2. In these patients, consider hydration or MRE.
   3. Patients who have had multiple CT examinations in their lifetime and in whom the examination is not considered urgent or emergent. In such cases, consider MRE, especially in younger patients with Crohn's disease
   4. Patients in the postoperative period (within 2-3 weeks) in whom an abscess or anastomotic leak is considered more likely; this will require the use of a positive oral contrast agent, either orally and/or rectally if there is an anastomosis, rather than CTE. In the acute, emergency department setting, the choice of a conventional CT with positive or high attenuation oral contrast or a CTE should be based upon whether the patient is in the postoperative period or not. If the patient is not in the postoperative period and there is a history of Crohn's disease, a CTE should be considered.
   5. In pediatric patients, the relative advantages and disadvantages of CTE and MRE should be considered. In particular, the potential need for sedation/anesthesia should be weighed cautiously.

Clinical Scenarios in which CTE may not be Efficacious

CTE is not efficacious without IV contrast. The issues related to the use of gadolinium-based and iodinated contrast media in patients with acute and chronic kidney disease have recently been addressed and significantly changed when compared with prior recommendations. It is beyond the scope of this practice parameter to address these issues. Any questions concerning the appropriate use of these contrast agents for CTE and MRE should be addressed in the ACR Manual on Contrast Media [23]. It documents the use of low and iso-osmolality iodinated contrast media in CTE in patients with stable renal function and an eGFR of > 30 mL/min/1.73 m^2. The risk of contrast-induced nephropathy is low or nonexistent, all other factors being equal. The use of group II gadolinium-based contrast agents in MRE in any patient with acute or chronic kidney disease is now considered to be safe.

Patients with inflammatory bowel disease who have had multiple prior CT examinations and are not acutely ill may be better evaluated with MRE rather than with CTE. This particularly applies in the pediatric population, for

whom efforts to apply ALARA principles should be maintained. In the perioperative period, even in patients with Crohn's disease, an anastomotic leak may not be identified when neutral oral contrast medium is used. Lastly, there is no evidence that CTE can detect the cause of incomplete, low-grade, or recurrent small-bowel obstructions, which are commonly due to adhesive disease. These patients are better evaluated with a standard, fluoroscopic small-bowel follow-through series [24].

In this patient cohort, an MRE without IV contrast may be preferred.

For the pregnant or potentially pregnant patient, see the ACR–SPR Practice Parameter for Imaging Pregnant or Potentially Pregnant Patients with Ionizing Radiation [25].

III. QUALIFICATIONS OF PERSONNEL

See the ACR Practice Parameter for Performing and Interpreting Diagnostic Computed Tomography (CT) [26].

IV. SPECIFICATIONS OF THE EXAMINATION

The written or electronic request for CT enterography should provide sufficient information to demonstrate the medical necessity of the examination and allow for the proper performance and interpretation of the examination.

Documentation that satisfies medical necessity includes 1) signs and symptoms and/or 2) relevant history (including known diagnoses). The provision of additional information regarding the specific reason for the examination or a provisional diagnosis would be helpful and may at times be needed to allow for the proper performance and interpretation of the examination.

The request for the examination must be originated by a physician or other appropriately licensed health care provider. The accompanying clinical information should be provided by a physician or other appropriately licensed health care provider familiar with the patient's clinical problem or question and consistent with the state scope of practice requirements. (ACR Resolution 35 adopted in 2006 – revised in 2016, Resolution 12-b)

Oral Contrast Media for CTE

CTE requires some form of bowel distension to accurately assess the small bowel [18,19,27-29], including the interface between the wall and the lumen. Traditional positive contrast agents obscure this interface; therefore, oral agents currently used for CTE are much lower in attenuation, generally 0 - 30 HU, depending upon the agent, and are called neutral oral agents. Water, milk, lactulose, polyethylene glycol, methylcellulose, sorbitol, mannitol, a commercially available sugar alcohol beverage, and a commercially available 0.1% barium suspension are all currently in use as neutral oral contrast agents [11,30-38]. The 0.1% barium suspension has a density between 15 and 25 HU. Attenuation depends upon the location in the bowel and amount of water absorption. CTE neutral oral contrast agents retard absorption of water along the length of the small bowel, maintaining distension and allowing for bowel-wall assessment. Because water is absorbed over the length of the small bowel, use of specially designed oral contrast agents is preferred for CTE (see below for exceptions).

Oral Contrast Media Ingestion Regimens

CTE oral contrast ingestion protocols vary between institutions [11,30-38]. Regardless, oral contrast must be ingested over 30 - 60 minutes. CT image acquisition is generally begun after 45 to 70 minutes for patients with an intact gastrointestinal system and 30–45 minutes for patients with surgically altered intestinal anatomy. The volume of contrast ingested varies, but most adult protocols require the ingestion of 1,000 - 1,350 mL of contrast agent, and in pediatric patients, the volume varies and is prescribed according to patient weight, eg, 20 mL/kg, up to adult dose), and often supplemented at the end by water. The water is administered just before the scan acquisition in an attempt to distend the duodenum and jejunum. It is best for the patient to consistently ingest the oral contrast material over the time period, rather than rapidly ingest each bottle of contrast. This method will facilitate consistent proximal-to-distal small-bowel distension. Ideally, the patients should be located in the radiology department while ingesting the contrast so that a technologist, nurse, or designated individual can directly observe the patients and identify those who are having trouble ingesting the agent, and provide

encouragement. Patient compliance with enteric contrast drinking can be enhanced by contrast refrigeration or addition of sugar-free flavoring. Ileal distension appears to improve when the patient ingests the agent while sitting or supine, as opposed to in the right lateral decubitus position [37]. If the patient cannot ingest the oral contrast agent, an enteric tube can be placed for administration and removed prior to imaging. Alternatively, if the patient has ingested some contrast medium, the required balance can be completed with water. Some sites encourage patients to ingest a few sips of water between bottles of the commercially available 0.1% barium suspension, to aid patient compliance. If only water is used, imaging should be performed earlier (ie, 30 minutes after beginning drinking) as water is rapidly absorbed. If patients are unable to drink the prescribed volume of neutral oral contrast agent, the supervising physician should make the determination whether the patient should substitute water for the remaining volume of contrast or continue the study.

IV Contrast Enhancement for CTE

For CTE, IV contrast enhancement is essential for the assessment of bowel wall enhancement pattern, enhancing bowel wall lesions and intraluminal contrast extravasation, in the case of acute gastrointestinal bleeding. Scan timing relative to the start of iodinated contrast injection for CTE is somewhat variable. Schindera et al reported that the normal small-bowel wall appears to have the greatest level of enhancement during the enteric phase (approximately 40 seconds postinitiation of contrast injection) [39]. This investigation did not take into account the location of the small bowel when assessing bowel wall enhancement, which is relevant because the normal number of folds decreases from duodenum to ileum, and the duodenum enhances more than the jejunum and the jejunum more than the ileum [1]. Thus, some investigators believe that the ideal time to scan in patients with Crohn's disease is at 50 seconds (or 14 seconds after peak abdominal aortic enhancement) after initiating contrast injection, although if the injection rate is limited by technical factors, timing should be delayed. Other investigators using timed MR scanning after an injection of contrast have shown that the maximal difference between normal and active inflammatory small-bowel Crohn's disease occurs much later, even several minutes after contrast injection [40]. Furthermore, an investigation of CTE showed that the detection of active inflammatory small-bowel Crohn's disease did not differ between scans obtained after 40 seconds and 70 seconds post contrast enhancement [41]. In most academic institutions, CTE obtained for assessment of Crohn's disease is performed using a single phase of enhancement acquired between 50 and 70 seconds post contrast injection (ie, either the enteric or portal venous phase). Recently, a split-bolus technique has been investigated, yielding a greater contrast-to-noise ratio for active Crohn's disease and improving disease detection [42].

In the evaluation of suspected small-bowel bleeding , suspected chronic mesenteric ischemia, and suspected small-bowel masses, multiphasic scanning is essential [7-10]. Some centers perform a low-dose precontrast evaluation to eliminate the confusion that high-attenuation, intraluminal objects, such as pills, may cause (any intraluminal high-attenuation object that does not change during multiple postcontrast phases must be considered as inert and not significant). Most perform an arterial phase examination, with scan timing based on bolus tracking techniques, with a region of interest placed over the aorta at the diaphragmatic hiatus. This is followed by an enteric phase examination at approximately 50 seconds post contrast injection as well as a more delayed portal venous phase for even longer, >70–80 seconds. Some centers only perform arterial and portal venous phase scans for these indications. If a dual-energy CT scanner is utilized, the unenhanced portion of the examination can be eliminated because virtual noncontrast images can be generated.

Scan Position and Range

Patients are scanned in the supine position through the abdomen and pelvis. Importantly, technologists should include the perineum in order to identify perianal fistulas and abscesses in patients with known or suspected Crohn's disease.

Reconstruction Techniques for CTE

For reconstruction purposes, CTE created from MDCT data sets must be processed in orthogonal planes, typically axial and coronal. Some sites routinely reconstruct in the sagittal plane; some only when this plane provides additional information to a specific case, or for presurgical planning. Multiplanar reconstructions facilitate the identification of fistulae and sinus tracts. The sagittal plane is particularly helpful in identifying the origin of the

celiac axis and superior mesenteric artery and assessing for stenosis or occlusion in patients with suspected acute or chronic mesenteric ischemia. In patients scanned for vascular disease, 3-D angiograms can be easily reconstructed with various techniques on modern workstations. Modern workstations can also allow for assessment of the scan data in unlimited planes. The combination of axial, coronal, and sagittal planes can be utilized and helpful in identifying fistulae, sinus tracts, and presurgical planning. Maximum intensity projection (MIP) images are helpful particularly in multiphasic gastrointestinal bleeding studies to quickly assess for sites of active extravasation or focal enhancing masses. In patients with Crohn's disease, reconstructing 10-mm, coronal, thick MIP images facilitates the detection of chronic mesenteric vein occlusion.

V. DOCUMENTATION

Reporting should be in accordance with the ACR Practice Parameter for Communication of Diagnostic Imaging Findings [43].

The 2018 SAR/American Gastroenterogical Association (AGA)/SPR consensus document recommends that a templated, standardized reporting method be used for CTE in Crohn's disease [44]. Others recommend this as well [18,19,45-47]. Systematic reporting using a template and standardized terms for the findings and conclusions will facilitate communication and allow for outcomes measures. Findings on CTE and MRE are increasingly important in directing both medical and surgical management [48-52]; therefore, consistency in reporting is critical. The report should specifically indicate that the abdomen and pelvis CT with oral and IV contrast was a CTE examination utilizing neutral oral contrast media. Additionally, every effort should be made to use the standardized terms for radiographic findings of Crohn's disease as well as the accepted impressions summarizing those findings [44].

As an example, the report should address the following for patients with Crohn's disease (for non-Crohn's patients, the template can be adjusted to the specific disease process (eg, suspected small-bowel bleeding) :

- Presence, location, number, and length of disease segments (describe where wall thickening and abnormal enhancement are present)
- Presence of luminal narrowing without and with upstream dilation
- Presence of penetrating disease, including sinus tracts and fistulae
- Presence of inflammatory mass (or phlegmon, a term no longer recommended) and abscess
- Presence of ancillary findings: vasa recta distension, fibrofatty proliferation, perienteric edema, or inflammatory mass, gallstones, renal stones, mesenteric venous thrombosis, sacroiliitis, or avascular necrosis of hips

The impressions for CTE recommended by the SAR/AGA/SPR consensus are:

- Nonspecific small-bowel inflammation
- Active inflammatory small-bowel Crohn's disease without luminal narrowing
- Active inflammatory small-bowel Crohn's disease with luminal narrowing
- Crohn's disease with no imaging signs of active inflammation
- Stricture with imaging findings of active inflammation
- Stricture without imaging findings of active inflammation
- Penetrating Crohn's disease (often with luminal narrowing or stricture with imaging findings of active inflammation)
- Perianal Crohn's disease
- Other complications of Crohn's disease (eg, gallstones, nephrolithiasis, primary sclerosing cholangitis, or aseptic necrosis of femoral heads)
- Other important non-Crohn's disease findings

For specific issues regarding CT quality control, see the ACR Practice Parameter for Performing and Interpreting Diagnostic Computed Tomography (CT) **[**26**].**

VI. EQUIPMENT SPECIFICATIONS

Equipment performance monitoring should be in accordance with the ACR–AAPM Technical Standard for Diagnostic Medical Physics Performance Monitoring of Computed Tomography (CT) Equipment [53].

A. Performance Parameters

To achieve acceptable clinical CT scans of the small bowel, a CT scanner should meet or exceed the following capabilities [18]:

1. MDCT with detector row ≥16
2. Helical or volume acquisition with appropriate adaptation of pitch so that images of the abdomen and pelvis are acquired in a single breath-hold
3. Scan rotation time: =1 sec
4. Minimum slice thickness: <2 mm; maximum slice thickness: 3–4 mm
5. Limiting spatial resolution: =8 lp/cm for =32 cm display field of view (DFOV) and =10 lp/cm for <24 cm DFOV
6. Creation of multiplanar images (minimum axial and coronal; sagittal images added for disease process)

With the proliferation of dual-energy CT scanners (fast-switch kVp, dual-source or dual-layer, detector based), many sites are beginning to scan patients to create monoenergetic low keV (generally 50 keV) and iodine-map images. Some have found that these scanners more easily and accurately detect disease yet with no increased radiation exposure and with the ability to decrease the volume of iodinated contrast media administered [54,55]. An alternate solution is to utilize low kVp to accentuate areas of abnormal enhancement. This approach is especially useful in smaller patients, whereas in larger patients this may result in greater noise.

B. Appropriate emergency equipment and medications must be immediately available to treat adverse reactions associated with administered medications. The equipment and medications should be monitored for inventory and drug expiration dates on a regular basis. The equipment, medications, and other emergency support must also be appropriate for the range of ages and sizes in the patient population.

C. A soft-copy workstation (PACS station) review capability should be available to radiologist and clinicians. CD or DVD capability also should be available. For additional information on image sharing and security, see the ACR–AAPM–SIIM Technical Standard for Electronic Practice of Medical Imaging [56] and the ACR–AAPM–SIIM Practice Parameter for Electronic Medical Information Privacy and Security [57].

VII. RADIATION SAFETY IN IMAGING

Radiologists, medical physicists, non-physician radiology providers**,** radiologic technologists, and all supervising physicians have a responsibility for safety in the workplace by keeping radiation exposure to staff, and to society as a whole, "as low as reasonably achievable" (ALARA) and to assure that radiation doses to individual patients are appropriate, taking into account the possible risk from radiation exposure and the diagnostic image quality necessary to achieve the clinical objective. All personnel who work with ionizing radiation must understand the key principles of occupational and public radiation protection (justification, optimization of protection, application of dose constraints and limits) and the principles of proper management of radiation dose to patients (justification, optimization including the use of dose reference levels). https://www-pub.iaea.org/MTCD/Publications/PDF/PUB1775_web.pdf

Nationally developed guidelines, such as the ACR's Appropriateness Criteria®, should be used to help choose the most appropriate imaging procedures to prevent unnecessary radiation exposure.

Facilities should have and adhere to policies and procedures that require ionizing radiation examination protocols (radiography, fluoroscopy, interventional radiology, CT) to vary according to diagnostic requirements and patient body habitus to optimize the relationship between appropriate radiation dose and adequate image quality. Automated dose reduction technologies available on imaging equipment should be used, except when inappropriate for a specific exam. If such technology is not available, appropriate manual techniques should be used.

Additional information regarding patient radiation safety in imaging is available from the following websites – Image Gently® for children (www.imagegently.org) and Image Wisely® for adults (www.imagewisely.org). These advocacy and awareness campaigns provide free educational materials for all stakeholders involved in imaging (patients, technologists, referring providers, medical physicists, and radiologists).

Radiation exposures or other dose indices should be periodically measured by a Qualified Medical Physicist in accordance with the applicable ACR Technical Standards. Monitoring or regular review of dose indices from patient imaging should be performed by comparing the facility's dose information with national benchmarks, such as the ACR Dose Index Registry and relevant publications relying on its data, applicable ACR Practice Parameters, NCRP Report No. 172, Reference Levels and Achievable Doses in Medical and Dental Imaging: Recommendations for the United States or the Conference of Radiation Control Program Director's National Evaluation of X-ray Trends; 2006, 2009, amended 2013, revised 2023 (Res. 2d).

Radiation Exposure Issues with CTE

CT contributes the largest, single source of man-made ionizing radiation to the American public, and this contribution has substantially increased since 2009 [58]. This is of special concern in patients with a chronic illness such as Crohn's disease, which often starts in childhood or adolescence, and who are more likely to undergo frequent imaging examinations.

Several studies have shown that some patients with Crohn's disease receive large cumulative exposures (over 100 mSv) over the course of their disease and often are examined with CT 2–3 times a year [59-65]. Given evidence that radiation exposure from CT scans in children may result in an increased risk of brain tumors and leukemia [66,67], CT dose optimization remains at the forefront of quality efforts in radiology, especially in pediatric patients. Notwithstanding these observations, however, the benefits of CT far outweigh potential risks in symptomatic patients with Crohn's disease. Two recent studies have shown that CT in emergency department patients with Crohn's disease results in substantial patient management changes in a large portion of these patients (particularly in patients with bowel obstruction and abscesses) [68,69]. Another study showed that about 50% of outpatients with known or suspected Crohn's disease had their management plans changed as a result of CTE [49]. The medical justification for CTE depends upon the perceived benefit versus risk for any particular patient as well as the availability and clinical feasibility of alternative imaging modalities, such as MRE.

In the last decade, there have been many investigations comparing full or standard exposure CTE with lower exposure CTE utilizing alterations in kVp and mAs appropriate to body habitus, weight, and body mass index (BMI), and altering the scan pitch. These changes can lead to an increase in the image noise that can be offset with newer image reconstruction algorithms, generally called iterative reconstruction, applied to the initial lower-exposure images to reduce noise [70-97]. Reductions from CT dose index (CTDIvol) between 15–20 mGy to < 10 mGy, and even below 5 mGy, have been achieved without apparent loss of efficacy. However, these lower-exposure techniques reconstructed with new noise-reducing algorithms often result in images that are unfamiliar to some radiologists. In the research setting, these examinations are often rated by readers as suboptimal or nondiagnostic [70,82]. What is not known is how these images are interpreted in day-to-day practice and whether these lower exposure examinations result in more equivocal interpretations.

In this evolving field, when CTE is performed, every effort should be made to reduce the radiation exposure as low as reasonably achievable (ALARA) and still achieve a diagnostic examination.

For radiation exposure reduction in patients with Crohn's disease, a very appropriate alternative to CTE is MRE. Comparisons of the two techniques show equivalent efficacy in detecting both uncomplicated and complicated Crohn's disease [44]. The advantage of CT is the rapid scan acquisition time and superior spatial resolution. The 3T magnet technology approaches the spatial resolution of CT, but MRE can be more challenging to perform because it is more affected by patient motion given the longer acquisition times. This is especially an issue for imaging young children and first-time MRI studies on patients. MRE, especially on a 3T, is more susceptible to bowel peristalsis, a problem that can be improved by the use of antiperistaltic agents such as glucagon, hyoscyamine sulfate, or scopolamine butyl bromide, which is not available in the United States. The challenges of MRE are offset by its superior signal-to-noise ratio and excellent tissue characterization when compared with CTE and avoidance of ionizing radiation. Furthermore, multiple pulse sequences can be performed. These advantages

make MRE a feasible and viable alternative to CTE.

In many institutions, adult patients over the age of 18 years with known or suspected Crohn's disease are imaged with CTE at presentation. This initial examination offers excellent spatial resolution, is unaffected by motion-related artifacts, and provides a baseline study. If subsequent follow-up examinations are indicated, a CTE can be substituted with MRE (see the ACR–SAR–SPR Practice Parameter for the Performance of Magnetic Resonance (MR) Enterography [22]), depending upon the clinical presentation and scanner availability. Acutely ill patients require rapid imaging in order to exclude an abscess. Thus, CTE is more appropriate in this population. Postoperative patients are best evaluated with CT using positive oral contrast agents in order to exclude an anastomotic leak (oral and/or rectal, positive contrast administration, depending upon the site of the anastomosis).

VIII. QUALITY CONTROL AND IMPROVEMENT, SAFETY, INFECTION CONTROL, AND PATIENT EDUCATION

Policies and procedures related to quality, patient education, infection control, and safety should be developed and implemented in accordance with the ACR Policy on Quality Control and Improvement, Safety, Infection Control, and Patient Education appearing under the heading *ACR Position Statement on Quality Control and Improvement, Safety, Infection Control and Patient Education* on the ACR website (https://www.acr.org/Advocacy-and-Economics/ACR-Position-Statements/Quality-Control-and-Improvement).

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REFERENCES

1. Baker ME, Walter J, Obuchowski NA, et al. Mural attenuation in normal small bowel and active

inflammatory Crohn's disease on CT enterography: location, absolute attenuation, relative attenuation, and the effect of wall thickness. AJR. American journal of roentgenology 2009;192:417-23.
2. Bodily KD, Fletcher JG, Solem CA, et al. Crohn Disease: mural attenuation and thickness at contrast-enhanced CT Enterography--correlation with endoscopic and histologic findings of inflammation. Radiology 2006;238:505-16.
3. Booya F, Fletcher JG, Huprich JE, et al. Active Crohn disease: CT findings and interobserver agreement for enteric phase CT enterography. Radiology 2006;241:787-95.
4. Elsayes KM, Al-Hawary MM, Jagdish J, Ganesh HS, Platt JF. CT enterography: principles, trends, and interpretation of findings. Radiographics : a review publication of the Radiological Society of North America, Inc 2010;30:1955-70.
5. Hara AK, Alam S, Heigh RI, Gurudu SR, Hentz JG, Leighton JA. Using CT enterography to monitor Crohn's disease activity: a preliminary study. AJR. American journal of roentgenology 2008;190:1512-6.
6. Hara AK, Leighton JA, Heigh RI, et al. Crohn disease of the small bowel: preliminary comparison among CT enterography, capsule endoscopy, small-bowel follow-through, and ileoscopy. Radiology 2006;238:128-34.
7. Hara AK, Walker FB, Silva AC, Leighton JA. Preliminary estimate of triphasic CT enterography performance in hemodynamically stable patients with suspected gastrointestinal bleeding. AJR. American journal of roentgenology 2009;193:1252-60.
8. Huprich JE, Barlow JM, Hansel SL, Alexander JA, Fidler JL. Multiphase CT enterography evaluation of small-bowel vascular lesions. AJR. American journal of roentgenology 2013;201:65-72.
9. Huprich JE, Fletcher JG, Fidler JL, et al. Prospective blinded comparison of wireless capsule endoscopy and multiphase CT enterography in obscure gastrointestinal bleeding. Radiology 2011;260:744-51.
10. Lee SS, Oh TS, Kim HJ, et al. Obscure gastrointestinal bleeding: diagnostic performance of multidetector CT enterography. Radiology 2011;259:739-48.
11. Megibow AJ, Babb JS, Hecht EM, et al. Evaluation of bowel distention and bowel wall appearance by using neutral oral contrast agent for multi-detector row CT. Radiology 2006;238:87-95.
12. Paulsen SR, Huprich JE, Fletcher JG, et al. CT enterography as a diagnostic tool in evaluating small bowel disorders: review of clinical experience with over 700 cases. Radiographics : a review publication of the Radiological Society of North America, Inc 2006;26:641-57; discussion 57-62.
13. Raptopoulos V, Schwartz RK, McNicholas MM, Movson J, Pearlman J, Joffe N. Multiplanar helical CT enterography in patients with Crohn's disease. AJR. American journal of roentgenology 1997;169:1545-50.
14. Rollandi GA, Curone PF, Biscaldi E, et al. Spiral CT of the abdomen after distention of small bowel loops with transparent enema in patients with Crohn's disease. Abdominal imaging 1999;24:544-9.
15. Wang Z, Chen JQ, Liu JL, Qin XG, Huang Y. CT enterography in obscure gastrointestinal bleeding: a systematic review and meta-analysis. Journal of medical imaging and radiation oncology 2013;57:263-73.
16. Wold PB, Fletcher JG, Johnson CD, Sandborn WJ. Assessment of small bowel Crohn disease: noninvasive peroral CT enterography compared with other imaging methods and endoscopy--feasibility study. Radiology 2003;229:275-81.
17. Gerson LB, Fidler JL, Cave DR, Leighton JA. ACG Clinical Guideline: Diagnosis and Management of Small Bowel Bleeding. The American journal of gastroenterology 2015;110:1265-87; quiz 88.
18. Baker ME, Hara AK, Platt JF, Maglinte DD, Fletcher JG. CT enterography for Crohn's disease: optimal technique and imaging issues. Abdominal imaging 2015;40:938-52.
19. Sheedy SP, Kolbe AB, Fletcher JG, Fidler JL. Computed Tomography Enterography. Radiologic clinics of North America 2018;56:649-70.
20. Gourtsoyianni S, Zamboni GA, Romero JY, Raptopoulos VD. Routine use of modified CT Enterography in patients with acute abdominal pain. European journal of radiology 2009;69:388-92.
21. Bruining DH. CT enterography: is it the current state-of-the-art for small bowel diagnostics? Dig Dis 2010;28:429-32.
22. American College of Radiology. ACR-SAR-SPR Practice Parameter for the Performance of Magnetic Resonance (MR) Enterography. Available at: https://www.acr.org/-/media/ACR/Files/Practice-Parameters/MR-Enterog.pdf. Accessed January 29, 2019.
23. American College of Radiology. ACR Manual on Contrast Media Available at: https://www.acr.org/-/media/ACR/Files/Clinical-Resources/Contrast_Media.pdf. Accessed August 21, 2019.
24. Kohli MD, Maglinte DD. CT enteroclysis in incomplete small bowel obstruction. Abdominal imaging 2009;34:321-7.

25. American College of Radiology. ACR–SPR Practice Parameter for Imaging Pregnant or Potentially Pregnant Patients with Ionizing Radiation. Available at: https://www.acr.org/-/media/ACR/Files/Practice-Parameters/Pregnant-Pts.pdf. Accessed January 29, 2019.
26. American College of Radiology. ACR Practice Parameter for Performing and Interpreting Computed Tomography (CT). Available at: https://www.acr.org/-/media/ACR/Files/Practice-Parameters/CT-Perf-Interpret.pdf. Accessed January 29, 2019.
27. Fletcher JG. CT enterography technique: theme and variations. Abdominal imaging 2009;34:283-8.
28. Huprich JE, Fletcher JG. CT enterography: principles, technique and utility in Crohn's disease. European journal of radiology 2009;69:393-7.
29. Ilangovan R, Burling D, George A, Gupta A, Marshall M, Taylor SA. CT enterography: review of technique and practical tips. The British journal of radiology 2012;85:876-86.
30. Kuehle CA, Ajaj W, Ladd SC, Massing S, Barkhausen J, Lauenstein TC. Hydro-MRI of the small bowel: effect of contrast volume, timing of contrast administration, and data acquisition on bowel distention. AJR. American journal of roentgenology 2006;187:W375-85.
31. Young BM, Fletcher JG, Booya F, et al. Head-to-head comparison of oral contrast agents for cross-sectional enterography: small bowel distention, timing, and side effects. Journal of computer assisted tomography 2008;32:32-8.
32. Hebert JJ, Taylor AJ, Winter TC, Reichelderfer M, Weichert JP. Low-attenuation oral GI contrast agents in abdominal-pelvic computed tomography. Abdominal imaging 2006;31:48-53.
33. Arslan H, Etlik Ö, Kayan M, Harman M, Tuncer Ý, Temizöz O. Peroral CT Enterography with Lactulose Solution: Preliminary Observations. American Journal of Roentgenology 2005;185:1173-79.
34. Koo CW, Shah-Patel LR, Baer JW, Frager DH. Cost-effectiveness and patient tolerance of low-attenuation oral contrast material: milk versus VoLumen. AJR. American journal of roentgenology 2008;190:1307-13.
35. Kolbe AB, Fletcher JG, Froemming AT, et al. Evaluation of Patient Tolerance and Small-Bowel Distention With a New Small-Bowel Distending Agent for Enterography. AJR. American journal of roentgenology 2016;206:994-1002.
36. Leduc F, De A, Rebello R, Muhn N, Ioannidis G. A Comparative Study of Four Oral Contrast Agents for Small Bowel Distension with Computed Tomography Enterography. Can Assoc Radiol J 2015;66:140-4.
37. Lee SB, Kim SH, Son JH, Baik JY. Evaluation of bowel distension and bowel wall visualization according to patient positions during administration of oral contrast media for CT enterography. The British journal of radiology 2017;90:20170352.
38. Dillman JR, Towbin AJ, Imbus R, Young J, Gates E, Trout AT. Comparison of Two Neutral Oral Contrast Agents in Pediatric Patients: A Prospective Randomized Study. Radiology 2018;288:245-51.
39. Schindera ST, Nelson RC, DeLong DM, et al. Multi-detector row CT of the small bowel: peak enhancement temporal window--initial experience. Radiology 2007;243:438-44.
40. Makanyanga J, Punwani S, Taylor SA. Assessment of wall inflammation and fibrosis in Crohn's disease: value of T1-weighted gadolinium-enhanced MR imaging. Abdominal imaging 2012;37:933-43.
41. Vandenbroucke F, Mortele KJ, Tatli S, et al. Noninvasive multidetector computed tomography enterography in patients with small-bowel Crohn's disease: is a 40-second delay better than 70 seconds? Acta Radiol 2007;48:1052-60.
42. Boos J, Fang J, Chingkoe CM, et al. Split-Bolus Injection Producing Simultaneous Late Arterial and Portal Venous Phases in CT Enterography: Preliminary Results. AJR. American journal of roentgenology 2017;209:1056-63.
43. American College of Radiology. ACR Practice Parameter for Communication of Diagnostic Imaging Findings. Available at: https://www.acr.org/-/media/ACR/Files/Practice-Parameters/CommunicationDiag.pdf. Accessed January 29, 2019.
44. Bruining DH, Zimmermann EM, Loftus EV, Jr., et al. Consensus Recommendations for Evaluation, Interpretation, and Utilization of Computed Tomography and Magnetic Resonance Enterography in Patients With Small Bowel Crohn's Disease. Gastroenterology 2018;154:1172-94.
45. Al-Hawary MM, Kaza RK, Platt JF. CT enterography: concepts and advances in Crohn's disease imaging. Radiologic clinics of North America 2013;51:1-16.
46. Wildman-Tobriner B, Allen BC, Bashir MR, et al. Structured reporting of CT enterography for inflammatory bowel disease: effect on key feature reporting, accuracy across training levels, and subjective assessment of disease by referring physicians. Abdom Radiol (NY) 2017;42:2243-50.

47. Rees MA, Dillman JR, Anton CG, et al. Inter-radiologist agreement using Society of Abdominal Radiology-American Gastroenterological Association (SAR-AGA) consensus nomenclature for reporting CT and MR enterography in children and young adults with small bowel Crohn disease. Abdom Radiol (NY) 2019;44:391-97.
48. Bruining DH, Loftus EV, Jr., Ehman EC, et al. Computed tomography enterography detects intestinal wall changes and effects of treatment in patients with Crohn's disease. Clinical gastroenterology and hepatology : the official clinical practice journal of the American Gastroenterological Association 2011;9:679-83 e1.
49. Bruining DH, Siddiki HA, Fletcher JG, et al. Benefit of computed tomography enterography in Crohn's disease: effects on patient management and physician level of confidence. Inflammatory bowel diseases 2012;18:219-25.
50. Pariente B, Cosnes J, Danese S, et al. Development of the Crohn's disease digestive damage score, the Lemann score. Inflammatory bowel diseases 2011;17:1415-22.
51. Pariente B, Peyrin-Biroulet L, Cohen L, Zagdanski AM, Colombel JF. Gastroenterology review and perspective: the role of cross-sectional imaging in evaluating bowel damage in Crohn disease. AJR. American journal of roentgenology 2011;197:42-9.
52. Rimola J, Ordas I, Rodriguez S, Ricart E, Panes J. Imaging indexes of activity and severity for Crohn's disease: current status and future trends. Abdominal imaging 2012;37:958-66.
53. American College of Radiology. ACR–AAPM Technical Standard for Diagnostic Medical Physics Performance Monitoring of Computed Tomography (CT) Equipment. Available at: https://www.acr.org/-/media/ACR/Files/Practice-Parameters/CT-Equip.pdf. Accessed January 29, 2019.
54. Lee SM, Kim SH, Ahn SJ, Kang HJ, Kang JH, Han JK. Virtual monoenergetic dual-layer, dual-energy CT enterography: optimization of keV settings and its added value for Crohn's disease. European radiology 2018;28:2525-34.
55. De Kock I, Delrue L, Lecluyse C, Hindryckx P, De Vos M, Villeirs G. Feasibility study using iodine quantification on dual-energy CT enterography to distinguish normal small bowel from active inflammatory Crohn's disease. Acta Radiol 2019;60:679-86.
56. American College of Radiology. ACR-AAPM-SIIM Technical Standard for Electronic Practice of Medical Imaging. Available at: https://www.acr.org/-/media/ACR/Files/Practice-Parameters/Elec-Info-Privacy.pdf. Accessed September 30, 2019.
57. American College of Radiology. ACR-AAPM-SIIM Practice Parameter for Information Privacy and Security. Available at: https://www.acr.org/-/media/ACR/Files/Practice-Parameters/Elec-Info-Privacy.pdf. Accessed September 30, 2019.
58. National Council on Radiation Protection and Measurements. Ionizing radiation exposure of the population of the United States. Report 160. Bethesda, MD: National Council on Radiation Protection and Measurements; 2009.
59. Brenner DJ. Should computed tomography be the modality of choice for imaging Crohn's disease in children? The radiation risk perspective. Gut 2008;57:1489-90.
60. Chatu S, Subramanian V, Pollok RC. Meta-analysis: diagnostic medical radiation exposure in inflammatory bowel disease. Alimentary pharmacology & therapeutics 2012;35:529-39.
61. Desmond AN, O'Regan K, Curran C, et al. Crohn's disease: factors associated with exposure to high levels of diagnostic radiation. Gut 2008;57:1524-9.
62. Jaffe TA, Gaca AM, Delaney S, et al. Radiation doses from small-bowel follow-through and abdominopelvic MDCT in Crohn's disease. AJR. American journal of roentgenology 2007;189:1015-22.
63. Kroeker KI, Lam S, Birchall I, Fedorak RN. Patients with IBD are exposed to high levels of ionizing radiation through CT scan diagnostic imaging: a five-year study. Journal of clinical gastroenterology 2011;45:34-9.
64. Palmer L, Herfarth H, Porter CQ, Fordham LA, Sandler RS, Kappelman MD. Diagnostic ionizing radiation exposure in a population-based sample of children with inflammatory bowel diseases. The American journal of gastroenterology 2009;104:2816-23.
65. Peloquin JM, Pardi DS, Sandborn WJ, et al. Diagnostic ionizing radiation exposure in a population-based cohort of patients with inflammatory bowel disease. The American journal of gastroenterology 2008;103:2015-22.
66. Brenner DJ, Hall EJ. Cancer risks from CT scans: now we have data, what next? Radiology 2012;265:330-1.
67. Pearce MS, Salotti JA, Little MP, et al. Radiation exposure from CT scans in childhood and subsequent risk of leukaemia and brain tumours: a retrospective cohort study. Lancet 2012;380:499-505.

68. Isreali E YS, Henderson, Mottola J, Strome T, Bernstein CN. The impact of abdominal computed tomography in a tertiary referral centre emergency deparment on the management of patients with inflammatory bowel disease. Alim Pharmacol Ther 2013;38:513-21.
69. Kerner C CK, Mills AM, et al. Use of computed tomography in emergency departments and rates of urgent diagnoses in Crohn's disease. Clinical gastroenterology and hepatology : the official clinical practice journal of the American Gastroenterological Association 2012;10:52-57.
70. Allen BC, Baker ME, Einstein DM, et al. Effect of altering automatic exposure control settings and quality reference mAs on radiation dose, image quality, and diagnostic efficacy in MDCT enterography of active inflammatory Crohn's disease. AJR. American journal of roentgenology 2010;195:89-100.
71. Craig O, O'Neill S, O'Neill F, et al. Diagnostic accuracy of computed tomography using lower doses of radiation for patients with Crohn's disease. Clinical gastroenterology and hepatology : the official clinical practice journal of the American Gastroenterological Association 2012;10:886-92.
72. Gonzalez-Guindalini FD, Ferreira Botelho MP, Tore HG, Ahn RW, Gordon LI, Yaghmai V. MDCT of chest, abdomen, and pelvis using attenuation-based automated tube voltage selection in combination with iterative reconstruction: an intrapatient study of radiation dose and image quality. AJR. American journal of roentgenology 2013;201:1075-82.
73. Guimaraes LS, Fletcher JG, Yu L, et al. Feasibility of dose reduction using novel denoising techniques for low kV (80 kV) CT enterography: optimization and validation. Academic radiology 2010;17:1203-10.
74. Hough DM, Fletcher JG, Grant KL, et al. Lowering kilovoltage to reduce radiation dose in contrast-enhanced abdominal CT: initial assessment of a prototype automated kilovoltage selection tool. AJR. American journal of roentgenology 2012;199:1070-7.
75. Kambadakone AR, Chaudhary NA, Desai GS, Nguyen DD, Kulkarni NM, Sahani DV. Low-dose MDCT and CT enterography of patients with Crohn disease: feasibility of adaptive statistical iterative reconstruction. AJR. American journal of roentgenology 2011;196:W743-52.
76. Kambadakone AR, Prakash P, Hahn PF, Sahani DV. Low-dose CT examinations in Crohn's disease: Impact on image quality, diagnostic performance, and radiation dose. AJR. American journal of roentgenology 2010;195:78-88.
77. Kaza RK, Platt JF, Al-Hawary MM, Wasnik A, Liu PS, Pandya A. CT enterography at 80 kVp with adaptive statistical iterative reconstruction versus at 120 kVp with standard reconstruction: image quality, diagnostic adequacy, and dose reduction. AJR. American journal of roentgenology 2012;198:1084-92.
78. Siddiki H, Fletcher JG, Hara AK, et al. Validation of a lower radiation computed tomography enterography imaging protocol to detect Crohn's disease in the small bowel. Inflammatory bowel diseases 2011;17:778-86.
79. Baker ME, Dong F, Primak A, et al. Contrast-to-noise ratio and low-contrast object resolution on full- and low-dose MDCT: SAFIRE versus filtered back projection in a low-contrast object phantom and in the liver. AJR. American journal of roentgenology 2012;199:8-18.
80. Feng C, Zhu D, Zou X, et al. The combination of a reduction in contrast agent dose with low tube voltage and an adaptive statistical iterative reconstruction algorithm in CT enterography: Effects on image quality and radiation dose. Medicine (Baltimore) 2018;97:e0151.
81. Rosenfeld G, Brown J, Vos PM, Leipsic J, Enns R, Bressler B. Prospective Comparison of Standard- Versus Low-Radiation-Dose CT Enterography for the Quantitative Assessment of Crohn Disease. AJR. American journal of roentgenology 2018;210:W54-W62.
82. Gandhi NS, Baker ME, Goenka AH, et al. Diagnostic Accuracy of CT Enterography for Active Inflammatory Terminal Ileal Crohn Disease: Comparison of Full-Dose and Half-Dose Images Reconstructed with FBP and Half-Dose Images with SAFIRE. Radiology 2016;280:436-45.
83. Ippolito D, Lombardi S, Trattenero C, Franzesi CT, Bonaffini PA, Sironi S. CT enterography: Diagnostic value of 4th generation iterative reconstruction algorithm in low dose studies in comparison with standard dose protocol for follow-up of patients with Crohn's disease. European journal of radiology 2016;85:268-73.
84. Murphy KP, Crush L, Twomey M, et al. Model-Based Iterative Reconstruction in CT Enterography. AJR. American journal of roentgenology 2015;205:1173-81.
85. Wallihan DB, Podberesky DJ, Sullivan J, et al. Diagnostic Performance and Dose Comparison of Filtered Back Projection and Adaptive Iterative Dose Reduction Three-dimensional CT Enterography in Children and Young Adults. Radiology 2015;276:233-42.
86. Fletcher JG, Hara AK, Fidler JL, et al. Observer performance for adaptive, image-based denoising and filtered

back projection compared to scanner-based iterative reconstruction for lower dose CT enterography. Abdominal imaging 2015;40:1050-9.
87. Goenka AH, Herts BR, Obuchowski NA, et al. Effect of reduced radiation exposure and iterative reconstruction on detection of low-contrast low-attenuation lesions in an anthropomorphic liver phantom: an 18-reader study. Radiology 2014;272:154-63.
88. Hernandez-Giron I, Geleijns J, Calzado A, Veldkamp WJ. Automated assessment of low contrast sensitivity for CT systems using a model observer. Medical physics 2011;38 Suppl 1:S25.
89. Husarik DB, Schindera ST, Morsbach F, et al. Combining automated attenuation-based tube voltage selection and iterative reconstruction: a liver phantom study. European radiology 2014;24:657-67.
90. Kanal KM, Chung JH, Wang J, et al. Image noise and liver lesion detection with MDCT: a phantom study. AJR. American journal of roentgenology 2011;197:437-41.
91. Pickhardt PJ, Lubner MG, Kim DH, et al. Abdominal CT with model-based iterative reconstruction (MBIR): initial results of a prospective trial comparing ultralow-dose with standard-dose imaging. AJR. American journal of roentgenology 2012;199:1266-74.
92. Schindera ST, Odedra D, Mercer D, et al. Hybrid Iterative Reconstruction Technique for Abdominal CT Protocols in Obese Patients: Assessment of Image Quality, Radiation Dose, and Low-Contrast Detectability in a Phantom. AJR. American journal of roentgenology 2014;202:W146-52.
93. Schindera ST, Odedra D, Raza SA, et al. Iterative reconstruction algorithm for CT: can radiation dose be decreased while low-contrast detectability is preserved? Radiology 2013;269:511-8.
94. Johnson E, Megibow AJ, Wehrli NE, O'Donnell T, Chandarana H. CT enterography at 100 kVp with iterative reconstruction compared to 120 kVp filtered back projection: evaluation of image quality and radiation dose in the same patients. Abdominal imaging 2014;39:1255-60.
95. von Falck C, Bratanova V, Rodt T, et al. Influence of sinogram affirmed iterative reconstruction of CT data on image noise characteristics and low-contrast detectability: an objective approach. PloS one 2013;8:e56875.
96. Murphy KP, Crush L, McLaughlin PD, et al. The role of pure iterative reconstruction in conventional dose CT enterography. Abdominal imaging 2015;40:251-7.
97. Son JH, Kim SH, Cho EY, Ryu KH. Comparison of diagnostic performance between 1 millisievert CT enterography and half-standard dose CT enterography for evaluating active inflammation in patients with Crohn's disease. Abdom Radiol (NY) 2018;43:1558-66.

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