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

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 Advanced Body Imaging (SABI), the Society of Abdominal Radiology (SAR), and the Society for Pediatric Radiology (SPR).

CT Enterography (CTE) is a multidetector CT (MDCT) examination using neutral oral contrast agents (with density of <20-30 HU) and intravenous (IV) contrast medium for the evaluation of small-bowel diseases [1-20]. CT and

MR Enterography (MRE) are recommended in the evaluation of small bowel diseases [21] and have supplanted traditional barium-based fluoroscopic techniques (small-bowel series and enteroclysis) [22] (see the ACR–SAR–SPR Practice Parameter for the Performance of Magnetic Resonance (MR) Enterography [23]).

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 including assessment of disease activity, extent, and distribution, not in the perioperative period
   2. Suspected Crohn disease or other causes of small-bowel inflammation
   3. Suspected small-bowel bleeding (formally obscure gastrointestinal bleeding). This study should be performed in hemodynamically stable patients after upper and lower endoscopy fail to identify bleeding. Single phase technique is sufficient for mass or inflammation detection, whereas multiphasic technique assists with vascular lesion characterization.
   4. Suspected small-bowel disease (eg, celiac disease, vasculitis, etc)
   5. Suspected small bowel tumors
   6. Chronic diarrhea and/or abdominal pain

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 less than 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 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 on whether the patient is in the postoperative period. If the patient is not in the postoperative period and there is a history of Crohn 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 during MRE 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 previous 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 [24]. It documents the use of low and iso-osmolar iodinated contrast media in CTE in patients with stable renal function and an eGFR of more than 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 previous CT examinations and are undergoing surveillance imaging may be better evaluated with MRE rather than with CTE, whereas acutely symptomatic patients would benefit from CTE. This particularly applies in the pediatric population, for whom efforts to apply as low as reasonably achievable (ALARA) principles should be maintained. In the perioperative period, even in patients with Crohn 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.

In pregnant patients, 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 uniform bowel distension to accurately assess the small bowel [18, 19, 27-29] including the interface between the wall and the lumen. Traditional positive oral contrast agents obscure the interface between the bowel wall and the lumen; therefore, oral agents used for CTE are much lower in attenuation, generally 0–30 HU, depending on the agent, and are called "neutral" oral contrast agents. Water, milk, lactulose, polyethylene glycol, methylcellulose, sorbitol, mannitol, dilute iohexol, and a commercially available sugar alcohol beverage are all currently in use as neutral oral contrast agents [11, 30-35]. Attenuation depends on 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, specially designed oral contrast agents are preferred for CTE instead of water (see below for exceptions).

Oral Contrast Media Ingestion Regimens

Patients should be fasting for 4–6 hours before the CTE examination to improve compliance and minimize filling defects within the small bowel. CTE oral contrast ingestion protocols vary among institutions [11, 30-35]. Regardless, oral contrast must be ingested over 30–60 minutes. CT image acquisition is generally begun after 45–70 minutes for patients with an intact gastrointestinal system and 30 to 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. For pediatric patients, the volume varies according to patient weight, for example, 20 mL/kg, up to adult dose. Water is often administered just before the scan acquisition in an attempt to distend the stomach and duodenum. It is best for the patient to consistently ingest oral contrast material over the time period, rather than rapidly ingest each bottle of contrast to ensure consistent bowel distention. Ideally, patients should be in the radiology department while ingesting the contrast so that a technologist, nurse, or designated individual can directly observe the patients to 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. If the patient cannot ingest the oral contrast agent, an enteric tube can be placed for administration and removed before imaging. Some sites encourage patients to ingest a few sips of water between bottles of oral contrast agent 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 determine whether water may be substituted for the remaining volume of contrast or if the study should be discontinued.

IV Contrast Enhancement for CTE

For CTE, IV contrast is essential for the assessment of bowel wall enhancement, the mural enhancement pattern, and the enhancement of bowel-wall lesions. Scan timing relative to contrast injection for CTE is somewhat variable. Schindera et al reported that the normal small-bowel wall appears to have the greatest enhancement during the enteric phase (approximately 40 seconds postinitiation of contrast injection) [36]. This investigation did not account for the location of the small bowel when assessing wall enhancement, which is relevant because the duodenum enhances more than the jejunum and the jejunum enhances more than the ileum [1]. Many investigators believe that the ideal time to scan patients with Crohn disease is at 50 seconds after initiating contrast injection (or 14 seconds after peak abdominal aortic enhancement), although if the injection rate is limited by technical factors, timing should be delayed. Furthermore, an investigation of CTE showed that the detection of active inflammatory small-bowel Crohn disease did not differ between scans obtained after 40 seconds and 70 seconds after contrast enhancement [37]. In most academic institutions, CTE obtained for assessment of Crohn disease is performed using a single phase acquired between 50 and 70 seconds after contrast injection (ie, either the enteric or portal venous phase). Recently, a study of a split-bolus technique suggests that this technique may yield a greater contrast-to-noise ratio for active Crohn disease and improve disease detection [38].

In the evaluation of suspected small-bowel bleeding (typically related to small bowel masses and vascular abnormalities) and suspected chronic mesenteric ischemia, 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 after contrast injection as well as a more delayed portal venous phase more than 70–80 seconds after contrast injection. Some centers only perform arterial and portal venous phase scans for these indications. If a dual-energy CT scanner is used, the unenhanced phase can potentially be eliminated because virtual noncontrast images can be generated. However, there may be subtraction issues and artifacts that can confuse interpretation.

Scan Position and Range

Patients are scanned in the supine position through the abdomen and pelvis. Importantly, technologists should include the perineum to identify perianal fistulas and abscesses in patients with known or suspected Crohn 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, whereas other sites choose to reconstruct in the sagittal plane on a case-by-case basis 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 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 used 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 active extravasation or focal enhancing masses. In patients with Crohn 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 [39].

The 2018 SAR/American Gastroenterogical Association/SPR consensus document recommends that a templated, standardized reporting method be used for CTE in Crohn disease [21]. Others recommend this, as well [18, 19, 40-42]. 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 [43-47]; 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 using neutral oral contrast media. Additionally, every effort should be made to use the standardized terms for radiographic findings of Crohn disease as well as the accepted impressions summarizing those findings [21].

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 [48].

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 photon counting and 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 . An alternate solution is to use low kVp to accentuate areas of abnormal enhancement. This approach is especially useful in smaller or pediatric patients, whereas in larger (or adult) 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.

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 [49]. This is of special concern in patients with a chronic illness such as Crohn 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 disease receive large cumulative exposures (more than 100 mSv) over the course of their disease and often are examined with CT 2–3 times a year [50-56]. Given evidence that radiation exposure from CT scans in children may result in an increased risk of brain tumors and leukemia [57, 58], 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 disease. Two recent studies have shown that CT in emergency department patients with Crohn disease results in substantial patient management changes in a large portion of these patients (particularly in patients with bowel obstruction and abscesses) [59, 60]. Another study showed that approximately 50% of outpatients with known or suspected Crohn disease had their management plans changed as a result of CTE [43]. The medical justification for CTE depends on 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 using alterations in kVp and mAs appropriate to body habitus, weight, and body mass index, 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 [61-88]. Reductions from CT dose index between 15 and 20 mGy to more than 10 mGy, and even below 5 mGy, have been achieved without apparent loss of efficacy.

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

For radiation exposure reduction in patients with Crohn disease, a very appropriate alternative to CTE is MRE. Comparisons of the two techniques show equivalent efficacy in detecting both uncomplicated and complicated Crohn disease [21]. 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 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 [23]), depending on the clinical presentation and scanner availability. Acutely ill patients require rapid imaging to exclude an abscess. Thus, CTE is more appropriate in this population. Postoperative patients are best evaluated with CT using positive oral contrast agents to exclude an anastomotic leak (oral and/or rectal, positive contrast administration, depending on the site of the anastomosis).

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

A Qualified Medical Physicist should perform an annual survey of the CT unit. More frequent QC tests should be performed by a trained CT technologist. These QC tests and their frequencies should be under the supervision of the Qualified Medical Physicist.

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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