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2015 (Resolution 18)*

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

PREAMBLE

These Practice Parameters are 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 care¹. For these reasons and those set forth below, the American College of Radiology cautions against the use of these Practice Parameters 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 physician or medical physicist in light of all the circumstances presented. Thus, an approach that differs from the Practice Parameters, standing alone, does not necessarily imply that the approach was below the standard of care¹. To the contrary, a conscientious practitioner may responsibly adopt a course of action different from that set forth in the Practice Parameters when, in the reasonable judgment of the practitioner, such course of action is indicated by the condition of the patient, limitations of available resources, or advances in knowledge or technology subsequent to publication of the Practice Parameters. However, a practitioner who employs an approach substantially different from these Practice Parameters is advised to document in the patient record information sufficient to explain the approach taken.

The practice of medicine involves not only the science, but also 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 these Practice Parameters 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 sole purpose of these Practice Parameters is to assist practitioners in achieving this objective.

¹Iowa Medical Society and Iowa Society of Anesthesiologists v. Iowa Board of Nursing, ___ N.W.2d ___ (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 developed collaboratively by the American College of Radiology (ACR) and the Society of Abdominal Radiology (SAR) (authors are members of both organizations).

CT enterography (CTE) is an examination using neutral oral contrast agents (<20–30 HU) as well as intravenous contrast, with multidetector CT (MDCT) in the evaluation of small-bowel diseases, primarily Crohn's disease and obscure gastrointestinal bleeding [1-16]. Currently, this examination is also used worldwide for evaluating acute and chronic mesenteric ischemia (in acute cases, oral contrast media administration may not be necessary), detecting small-bowel neoplasms (often in the setting of obscure gastrointestinal bleeding), and evaluating celiac disease, as well as in the in nontraumatic patients who have acute abdominal pain [17]. In most active large centers caring for Crohn's patients, CT and now MR enterography (MRE) – see the [ACR–SAR–SPR Practice Parameter for the Performance of Magnetic Resonance \(MR\) Enterography](#) – has become the standard of care and has supplanted traditional barium based fluoroscopic techniques (small-bowel series and enteroclysis) [18].

II. INDICATIONS AND CONTRAINDICATIONS

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

A. Indications

1. Known Crohn's disease not in the peri-operative period
2. Suspected Crohn's disease or other causes of small-bowel inflammation
3. Obscure gastrointestinal bleeding (must use multiphasic technique) (best after a negative upper and lower endoscopy)
4. Suspected small-bowel disease (e.g., celiac disease)
5. Chronic diarrhea and/or abdominal pain
6. Suspected chronic mesenteric ischemia

B. Contraindications (most are relative) Where Other Examinations May be More Efficacious

1. Patients with a known, severe iodinated contrast media allergy who are able to undergo a contrast enhanced MRE
2. Patients with chronic kidney disease, in whom iodinated contrast material or oral fluid volume is considered harmful.
3. Patients who have had multiple CT examinations in their lifetime and in whom the examination is not considered urgent or emergent (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, generally iodinated contrast, either orally or rectally if there is an anastomosis, rather than CTE.

Clinical Scenarios Where CTE May Not Be Efficacious

Patients with an eGFR <30 mL/min/1.73 m², who should not receive gadolinium agents, will likely be better assessed with nonenhanced MRE (relying on T2-weighted pulse sequences and diffusion-weighted imaging) rather than unenhanced CTE.

Crohn's disease patients who have had multiple prior CT examinations and are not acutely ill may be better evaluated with contrast enhanced MRE rather than with enhanced CTE. In the perioperative period, even in patients with Crohn's disease, an anastomotic leak will not be identified when neutral oral contrast media is used. Lastly, there is no evidence that CTE can detect the cause of incomplete, low-grade, or recurrent small-bowel obstructions, commonly due to adhesive disease. These patients are better evaluated with either a standard, fluoroscopic, or CT enteroclysis [19].

For the pregnant or potentially pregnant patient, see the [ACR–SPR Practice Parameter for Imaging Pregnant or Potentially Pregnant Adolescents and Women with Ionizing Radiation \[20\]](#). In this patient cohort, an MRE without intravenous contrast may be preferred.

III. QUALIFICATIONS OF PERSONNEL

See the [ACR SPR Practice Parameter for Performing and Interpreting Diagnostic Computed Tomography \(CT\) \[21\]](#).

IV. SPECIFICATIONS OF THE EXAMINATION

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

Documentation that satisfies medical necessity includes 1) signs and symptoms and/or 2) relevant history (including known diagnoses). 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's scope of practice requirements. (ACR Resolution 35, adopted in 2006)

Oral Contrast Media for CT Enterography

CTE requires some form of bowel distension in order to accurately assess the small bowel [22-24], including the interface between the wall and the lumen. Traditional, positive or high attenuation 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 termed neutral oral agents. Water, milk, lactulose, polyethylene glycol, methylcellulose, and a commercially available 0.1% barium suspension are all currently in use as neutral oral contrast agents [11,25-31]. The 0.1% barium suspension is between 15 and 25 HU in clinical practice. 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 [25,26]. 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 30–45 minutes for patients with ileocecal resections, ileostomies, multiple small-bowel resections, or total proctocolectomies with ileo-anal pouch anastomoses. The volume of contrast ingested varies, but most protocols require the ingestion of at least 1350 cc of contrast agent (corresponds to 3 bottles of the commercially available 0.1% barium suspension), often supplemented at the end by water (immediately before the scan acquisition to distend the stomach and duodenum since water absorption is not a concern at this time). It is best for the patient to consistently and slowly ingest the contrast over the time period, rather than rapidly ingest each bottle of contrast. This method will facilitate consistent proximal-to-distal small-bowel distension. For the most consistent bowel distension, it is optimal that the patients ingesting the contrast be located in the radiology department such that a technologist or nurse can observe the patient both to encourage them to drink and to identify those patients who are having trouble ingesting the agent. Patient compliance with enteric contrast drinking can be enhanced by contrast refrigeration or addition of sugar-free fruit flavoring. If the patient cannot ingest the oral contrast agent, either a feeding tube or NG (nasogastric) tube can be placed to allow for administration, or the patient can be encouraged to drink the balance of the required volume with water. Some sites encourage patients to ingest a few sips of water between bottles of the commercially available 0.1% barium suspension. They have found that this simple method improves patient compliance. If only water is used, imaging should be performed earlier (ie, 30 minutes) 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.

Intravenous Contrast Enhancement for CT Enterography

For CTE, intravenous contrast enhancement is essential for the assessment of bowel-wall enhancement pattern, enhancing bowel-wall lesions or intra-luminal contrast extravasation, and in the case of acute gastrointestinal bleeding. Scan timing vis-à-vis 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 50 seconds, post initiation of contrast injection) [27]. This investigation did not take into account the location of the small bowel when assessing bowel-wall enhancement (because of the normal number of folds decreases from duodenum to ileum, the duodenum enhances more than the jejunum and the jejunum enhances more than the ileum) [1]. Some investigators believe that the ideal time to scan in patients with Crohn's disease is at 50 seconds post contrast. 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 [28]. Further, an investigation of CTE showed that the detection of active inflammatory small-bowel Crohn's disease was not different between scans obtained after 40 seconds and 70 seconds post contrast enhancement [29]. 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).

In the evaluation of obscure gastrointestinal bleeding, suspected acute or chronic mesenteric ischemia, and suspected small-bowel masses, multiphasic scanning is essential [8,9]. Some centers perform a low-dose precontrast evaluation in order 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 phases, postcontrast 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 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 or even longer, >70–80 seconds. Some centers only perform arterial and portal venous phase scans for these indications.

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 CT Enterography

For reconstruction purposes, CTE created from MDCT datasets 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. 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. However, it is best to provide the referring gastroenterologist and surgeon at least the axial and coronal planes. Both specialists are most familiar with evaluating the small bowel in the frontal or coronal plane, the plane that most imitates the overhead films routinely obtained in a small-bowel barium series. 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.

V. DOCUMENTATION

Reporting should be in accordance with the [ACR Practice Parameter for Communication of Diagnostic Imaging Findings \[32\]](#).

It is recommended that a templated, standardized reporting method be used for CTE in Crohn's disease [33]. 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 [34-38]. The report should indicate that CTE was performed.

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 (ie, obscure gastrointestinal bleeding)):

- Presence, location, number & 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 & fistulae
- Presence of 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

In the conclusion, the following terms can be used (it should be noted that these terms are currently under consideration by a multidisciplinary group of gastrointestinal radiologists, gastroenterologists, and bowel surgeons and may change over time):

- Active inflammatory small-bowel Crohn's disease
- Quiescent or inactive small-bowel Crohn's disease
- Stricturing disease with or without findings of active inflammation (This term should only be used if there is both luminal narrowing and upstream bowel dilation >3 cm.)
- Penetrating Crohn's disease (in addition to active or stricturing disease; most often occurs with stricturing disease)

A standardized nomenclature and reporting template for findings is being developed by the Small Bowel Special Interest Group of the SAR in conjunction with gastrointestinal and colorectal surgery societies in order to achieve effective communication. The use of a standardized nomenclature and reporting template will address the important issues in Crohn's disease.

VI. EQUIPMENT SPECIFICATIONS

A. Performance Parameters

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

1. MDCT with detector row ≥ 16
2. Helical acquisition with appropriate adaptation of pitch so that images of the abdomen and pelvis are acquired in a single breathhold
3. Scan rotation time: ≤ 1 sec
4. Minimum slice thickness: ≤ 2 mm; Maximum slice thickness 3–4 mm with overlapping reconstructions
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)

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.

VII. RADIATION SAFETY IN IMAGING

Radiologists, medical physicists, registered radiologist assistants, 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 that work with ionizing radiation must understand the key principles of occupational and public radiation protection (justification, optimization of protection and application of dose limits) and the principles of proper management of radiation dose to patients (justification, optimization and the use of dose reference levels) http://www-pub.iaea.org/MTCD/Publications/PDF/Pub1578_web-57265295.pdf.

Nationally developed guidelines, such as the ACR's [Appropriateness Criteria](#)[®], should be used to help choose the most appropriate imaging procedures to prevent unwarranted radiation exposure.

Facilities should have and adhere to policies and procedures that require varying ionizing radiation examination protocols (plain radiography, fluoroscopy, interventional radiology, CT) to take into account patient body habitus (such as patient dimensions, weight, or body mass index) to optimize the relationship between minimal radiation dose and adequate image quality. Automated dose reduction technologies available on imaging equipment should be used whenever appropriate. If such technology is not available, appropriate manual techniques should be used.

Additional information regarding patient radiation safety in imaging is available at the Image Gently[®] for children (www.imagegently.org) and Image Wisely[®] for adults (www.imagewisely.org) websites. 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 measured and patient radiation dose estimated for representative examinations and types of patients by a Qualified Medical Physicist in accordance with the applicable ACR technical standards. Regular auditing of patient dose indices should be performed by comparing the facility's dose information with national benchmarks, such as the ACR Dose Index Registry, the 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. (ACR Resolution 17, adopted in 2006 – revised in 2009, 2013, Resolution 52).

Radiation Dose Issues With CT Enterography

CT contributes the largest, single source of manmade ionizing radiation to the American public, and this contribution continues to increase [30]. This is of special concern in patients with a chronic illness such as Crohn's disease, often starting in childhood or adolescence, and who are more likely to undergo frequent imaging examinations.

Several studies have shown that some Crohn's patients can receive large cumulative doses (over 100 mSv) over the course of their disease and often are examined with CT 2–3 times a year [31,39–44]. In one series encompassing a 15-year period of time, the mean ionizing radiation dose was 36.1 mSv. Over the entire study period there was an increasing use of CT, and although CT accounted for only 16.2% of all imaging studies, it accounted for 77.2% of the radiation dose. Further in this study, the total ionizing radiation exceeded 75 mSv in 15.5% of the patients [40]. Crohn's patients with onset of disease before 17 years of age, who have upper gastrointestinal tract or penetrating disease, who require intravenous steroids or infliximab, or who have had multiple surgeries receive higher doses. [31,40]. Given the recent evidence that radiation exposure from CT scans in children results in an increased risk of brain tumors and leukemia [45,46], CT dose reduction is at the forefront of quality efforts in radiology. Notwithstanding these observations, however, the benefits of CT far outweigh potential risks in symptomatic Crohn's patients. Two recent studies have shown that CT in emergency department patients with Crohn's disease results in substantial patient management changes in a large proportion of these patients (particularly in patients with bowel obstruction and abscesses) [47,48]. 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 [35]. One of these groups consequently concluded, "These numbers reflect the fact that patients with Crohn's disease are at high risk for complications given the nature of the disease and the risks of immunosuppression. Although radiation exposure in patients with Crohn's disease is a concern, clinicians must also weigh the risk of missing a potential urgent diagnosis when they forego a CT" [48]. The medical justification for CTE depends upon the perceived benefit versus the risk for any particular patient.

Efforts to reduce the dose from CT are ongoing and include alterations in kVp and mAs appropriate to body habitus, weight, and 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 termed iterative reconstruction, applied to the initial lower dose images to reduce noise [49–57]. Dose reductions from CTDIvol of 15–20 mGy to < 10 mGy and even below 5 mGy have been achieved.

It remains to be seen whether sub-milli Sievert imaging is possible without data loss. Crohn's disease identification in the small bowel is a high-contrast issue with CT (ie, identifying a process with a higher attenuation versus background; small-bowel wall hyperenhancement is a primary finding in active inflammatory Crohn's disease). Recent investigations have shown that low-contrast objects (an object of lower attenuation versus background) can be lost with lower dose CT even using iterative reconstruction techniques, including model-based iterative reconstruction [58–66].

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

investigations have already shown that diagnostic examinations can be achieved using lower dose techniques, techniques that result in doses much lower than many radiologists are familiar with, and resulting in examinations that radiologists unfamiliar with the new changes judge as suboptimal or nondiagnostic [49-57].

For radiation dose reduction in patients with Crohn's disease, a very appropriate alternative to CTE is MRE. Comparisons of the 2 techniques show equivalent efficacy in detecting both uncomplicated and complicated disease. The advantage of CT is the rapid scan acquisition time and superior spatial resolution. 3T magnet technology approaches the spatial resolution of CT. MRE may be more challenging to perform since it is more likely to be 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 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 the superior signal-to-noise ratio and excellent tissue characterization when compared to CTE. These advantages make MRE a feasible and viable alternative to CTE.

In most institutions, adult patients over the age of 18 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, depending upon the clinical presentation and scanner availability. Acutely ill patients require rapid imaging in order to exclude an abscess. 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 *Position Statement on QC & Improvement, Safety, Infection Control, and Patient Education* on the ACR website (<http://www.acr.org/guidelines>).

For specific issues regarding CT quality control, see the [ACR Practice Parameter for Performing and Interpreting Computed Tomography \(CT\) \[21\]](#).

Equipment performance monitoring should be in accordance with the [ACR–AAPM Technical Standard for Diagnostic Medical Physics Performance Monitoring of Computed Tomography \(CT\) Equipment \[67\]](#).

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