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

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

Computed tomography (CT) is a radiologic modality that utilizes ionizing radiation to obtain cross-sectional

images of a patient. The images are acquired in the patient's axial plane and may also be reprocessed to produce images in many additional anatomic planes or may be processed to produce volumetric data sets of structures like organs, vessels, or bones. Optimal performance of CT requires knowledge of anatomy and pathophysiology, familiarity with the basic physics and techniques of CT, and knowledge of radiation safety. This practice parameter outlines the principles for performing high-quality diagnostic abdominal CT and/or pelvic CT examinations.

II. INDICATIONS AND CONTRAINDICATIONS

A. Indications for abdominal CT and/or pelvic CT examinations include, but are not limited to:

1. Evaluation of abdominal, flank, or pelvic pain, including evaluation of suspected or known urinary calculi [1-3] and appendicitis [4-6]
2. Evaluation of abdominal or pelvic trauma [7-11]
3. Evaluation of renal and adrenal masses and of urinary tract abnormalities with CT urography [12-16]
4. Evaluation of known or suspected abdominal or pelvic masses or fluid collections, including gynecological masses [17-20]
5. Evaluation of primary or metastatic malignancies, including lesion characterization (eg, focal liver lesion) [21-24], staging, and treatment monitoring
6. Surveillance following locoregional therapies in abdominal malignancies, including percutaneous ablation, intra-arterial therapies (transarterial chemoembolization, selective interstitial radiation therapy), and targeted image-guided radiation therapy [25-28]
7. Assessment for recurrence of tumors following surgical resection [29-31]
8. Detection of complications following abdominal and pelvic surgery (eg, abscess, lymphocele, radiation change, and fistula/sinus tract formation [32-36]
9. Evaluation of diffuse liver disease (eg, cirrhosis, steatosis, iron deposition disease [37-40]) and disease of the biliary system [41-43]
10. Evaluation of abdominal or pelvic inflammatory and/or infectious processes, including inflammatory bowel disease, infectious bowel disease and its complications, without or with CT enterography [44-50], and of known or suspected renal or retroperitoneal infection
11. Assessment of abnormalities of abdominal or pelvic vascular structures [51-54]; noninvasive angiography of the aorta and its branches and noninvasive venography [55-58]
12. Clarification of findings from other imaging studies or laboratory abnormalities
13. Evaluation of known or suspected congenital abnormalities of abdominal or pelvic organs [59-61]
14. Evaluation for bowel obstruction or gastrointestinal bleeding [62-67]
15. Screening and diagnostic evaluation for colonic polyps and cancers with CT colonography [68-72]
16. Guidance for interventional or therapeutic procedures within the abdomen or pelvis [73-78]
17. Follow-up evaluation after interventional or therapeutic procedures within the abdomen or pelvis, including abscess drainage [79-82]
18. Treatment planning for radiation and chemotherapy and evaluation of tumor response to treatment [83-89]
19. Pre- and posttransplant assessment [90-95]

B. There are no absolute contraindications to abdominal CT or pelvic CT examinations. As with all procedures, the relative benefits and risks of the procedure should be evaluated before performing abdominal or pelvic CT, with and/or without the administration of intravenous (IV) iodinated contrast. Appropriate precautions should be taken to minimize patient risks, including radiation exposure and iodinated contrast delivery (see the ACR–SPR Practice Parameter for the Use of Intravascular Contrast Media [96] and the ACR Manual on Contrast Media [97]).

For the pregnant or potentially pregnant patient, see the ACR–SPR Practice Parameter for Imaging Pregnant or Potentially Pregnant Patients with Ionizing Radiation [98].

III. QUALIFICATIONS AND RESPONSIBLITIES OF PERSONNEL

See the ACR Practice Parameter for Performing and Interpreting Diagnostic Computed Tomography (CT) [99].

IV. SPECIFICATIONS OF THE EXAMINATION

The written or electronic request for a CT of the abdomen and/or CT of the pelvis 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 – revised in 2016, Resolution 12-b)

A. In general, a CT examination of the abdomen includes axial images from just above the dome of the diaphragm to the upper margin of the sacroiliac joints with a 5-mm or less slice thickness. A CT of the pelvis extends from the iliac crest through just below the ischial tuberosities with a 5-mm or less slice thickness (see Section VI). Occasionally, more inferior extension of imaging may be required to fully image pelvic structures of concern. Often, depending on the clinical indication for the study, both the abdomen and pelvis may be examined concurrently. Scans should be obtained through the entire area of interest. The scan field of view (FOV) and range should be optimized for each patient. Scans should generally be obtained during suspended respiration but may be obtained during free breathing for certain indications, such as radiation therapy planning.
B. The primary goal of CT scanning is to obtain diagnostic information from images of sufficient quality for the task. Protocols should be optimized to give the lowest radiation dose required to achieve appropriate image quality for a given task. This is especially important for radiosensitive groups, such as pediatric patients. Dose-reduction techniques should be considered when optimizing protocols. These techniques include, but are not limited to, automatic exposure control [100], automatic tube kV selection [101], iterative reconstruction [102], beam filtration [103], deep learning–based image reconstruction [104,105], and tube current modulation [106,107]. In certain cases, it may be appropriate to limit the area exposed and focus only on the area or organs of concern in order to limit the radiation dose. Choosing different mA (ie, image noise) and beam energy (ie, image contrast) as a function of indication allows for dose reduction in cases with high inherent contrast or low image quality tasks like skeletal structure evaluation [108-111].
C. In addition to axial images, at least one multiplanar reformation, such as coronal or sagittal images, should be reconstructed [112-116]. More complex oblique planes may be constructed from the source image data to answer specific clinical questions, to aid in disease visualization, or to assist in planning for interventional or surgical procedures. Additionally, 3-D reformations, such as maximum intensity projection (MIP), bone subtraction, and volume-rendered images may be reconstructed from the source image data or thin slices to clarify specific structures for studies such as CT angiography, CT urography, CT cystography, CT colonography, CT enterography, CT cholangiography, and/or other applications deemed necessary.
D. Abdominal and/or pelvic CT examinations may be performed during and/or after administering IV contrast medium using appropriate injection techniques [117,118]. The majority of clinical questions for abdominal and/or pelvic CT can be appropriately answered with a single-phase study. Multiple-phase studies, such as unenhanced, arterial, portal venous, or delayed-phase scanning, might be required in certain indications for improved detection and characterization of abnormalities, such as characterization of liver or renal lesions, detection of active bleeding, etc. For specific indications, it may be necessary to perform an unenhanced study first. Abnormal findings on an unenhanced examination may require further evaluation with IV contrast administration or an alternative imaging study if contrast medium is contraindicated. Administration of IV contrast is generally not required for certain indications such as dedicated evaluation of bony structures and assessment of urolithiasis.
E. An enteric contrast agent can be used in abdominal and pelvis CT scans. The choice to use an enteric agent and type should be determined on a case-by-case basis. Some indications may not require use of oral contrast [119,120]. In some clinical situations, such as trauma or altered mental status, oral contrast is contraindicated due to risk of aspiration. An intraluminal gastrointestinal contrast agent may be administered orally, rectally, or by nasogastric or other tube to provide adequate distention and visualization of the gastrointestinal tract. This agent may be a positive contrast agent, such as dilute barium or a water-soluble iodinated solution; a neutral contrast agent, such as water or a nonabsorbable agent

with similar x-ray attenuation as water; or a negative agent, such as air or carbon dioxide.

Positive oral contrast material provides improved delineation of abscesses, suspected leaks, peritoneal implants, and intra-abdominal tumors. Positive contrast may obscure the visualization of bowel wall enhancement or hypoenhancement. Positive contrast may also interfere with 3-D reformations of blood vessels. Barium agents, if used for CT, should be no more than 3% wt/wt.

Neutral enteric contrast agents provide bowel distention without obscuring bowel wall and therefore enable good visualization of bowel wall enhancement abnormalities and masses [121]. A variety of agents are available [121-123]. Water can be used if distention of only the proximal gastrointestinal tract is necessary. When distention of bowel beyond the proximal gastrointestinal tract is needed, contrast materials that contain materials less rapidly absorbed by the bowel can be used [124]. Neutral enteric contrast may reduce diagnostic accuracy for detection of abdominal fluid collections.

Negative enteric contrast agents are used predominantly for CT colonography but can also be used in other scenarios, such as gastric or esophageal imaging [125].

F. Window width and level settings should be adjusted appropriately to view the visceral organs, the intra-abdominal fat and muscles, the pulmonary parenchyma at the lung bases, and the osseous structures. Window width and level settings should be further adjusted for low kVp single-energy or low kiloelectron volt (keV) monochromatic dual-energy CT images.

G. Although many of the settings of a CT scanner are automated, a number of technical parameters remain operator dependent [126]. The supervising physician should be familiar with how individual CT settings affect radiation dose and image quality. These settings include the following:
    1. Automated exposure control [127]
    2. Iterative reconstruction and similar noise reduction techniques
    3. Tube potential (kVp)
    4. Gantry rotation time
    5. Detector configuration and z axis detector width for multidetector systems
    6. Reconstructed slice thickness and spacing
    7. Pitch or table increment
    8. FOV
    9. Reconstruction algorithm or kernel

    Dual, multienergy, and spectral CT techniques can be used to improve the diagnostic evaluation of multiple abdominopelvic tasks, including incidentaloma characterization, increasing contrast material conspicuity and decreasing artifacts from some metallic objects [128-136]. These techniques may be used to create virtual monoenenergetic and material selective reconstructions (including iodine maps and virtual noncontrast reconstructions); these may be utilized to eliminate an unenhanced acquisition and decrease radiation dose in certain situations [129,132,133,137,138].

    Low-kVp single-energy low keV monochromatic dual-energy images may also be used to reduce the volume of IV iodinated contrast medium. By nearing the iodine k edge (33.2 keV), these techniques can be used to increase the iodine conspicuity, thus compensating for the decreased volume of contrast medium administered, specifically for vascular applications [128,134].

H. Optimizing CT examination technique requires the supervising physician to select an appropriate CT protocol based on careful review of the patient history (to include risk factors that might increase the likelihood of adverse reactions to contrast media) and clinical indications, as well as all relevant imaging studies, when available. This optimization process may include determining whether CT examination of the abdomen, pelvis, or both is necessary. Adapting CT technique to accommodate patients with large body habitus is suggested with possible adjustments in acquisition technique and contrast injection parameters [139].

I. Protocols may be prepared by clinical indication and anatomy to be imaged [140]. Techniques should provide image quality consistent with the diagnostic needs of the examination at appropriate radiation dose levels [141-143]. For each area of interest or indication, the protocol should indicate the following:

1. The volume and type of intraluminal contrast media to be administered, the route of administration (oral, rectal, or via nasogastric, Foley catheter, or other tube), and the time intervals during which it should be delivered
2. If IV contrast material is used, the type, volume, rate of administration, and time delay(s) between administration and scan initiation. Bolus tracking or timing bolus should be used whenever indicated to optimize results [143-145].
3. Detector configuration
4. Pitch or table increment
5. Slice thickness
6. kVp and mAs per slice or range (minimum and maximum mAs for multidetector CT), as appropriate for adult or pediatric patients
7. Gantry rotation time
8. Automated exposure control
9. Reconstruction technique
10. Superior and inferior extent of the region of interest to be imaged
11. Reconstruction interval
12. Reconstruction kernel or algorithm
13. Reconstruction FOV
14. Instructions for which scans/images are sent to PACS
15. Use of 3-D and multiplanar reconstructions (MPR), where needed
16. For every CT examination, the information in the radiation dose report (CT dose index and dose length product) should be retained in the radiological record for future reference.

These protocols should be reviewed and updated periodically, and dated copies should be available to appropriate physicians and technical and administrative personnel at the facility. Each facility should review the scanner protocols periodically to confirm that they are in agreement with specified protocols.

V. DOCUMENTATION

Reporting should be in accordance with the ACR Practice Parameter for Communication of Diagnostic Imaging Findings [146].

VI. EQUIPMENT SPECIFICATIONS

A. Performance Guidelines
CT equipment specifications for imaging of pediatric patients may be found in the ACR-ASER-SCBT-MR-SPR Practice Parameter for the Performance of Pediatric Computed Tomography (CT) [147] and the ACR Practice Parameter for Performing and Interpreting Diagnostic Computed Tomography (CT) [99].

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. For additional information, refer to the ACR Manual on Contrast Media [97].

C. A soft-copy workstation (PACS station) review capability should be available to the radiologist. Remote viewing of images should also be available to authorized health care providers. A method should be available to transfer images outside the institution to authorized recipients.

Equipment monitoring and the continuous quality control program should be in accordance with the ACR–AAPM Technical Standard for Diagnostic Medical Physics Performance Monitoring of Computed Tomography (CT) Equipment [148].

For specific issues regarding CT quality control, see the ACR Practice Parameter for Performing and Interpreting Diagnostic Computed Tomography (CT) [99].

VII. RADIATION SAFETY IN IMAGING

When possible, CT imaging of the abdomen and pelvis should consider the following to minimize radiation dose and maintain image quality:

1. Center the patient in the gantry [149-153].
2. Keep the patient's arms above the abdomen [154,155].
3. Remove unnecessary, densely radiopaque objects from the patient.
4. Patient shielding that is partially exposed to the beam may increase radiation exposure because of the automated exposure control. Therefore, patient shielding is not recommended for abdominal CT [156].

Use of low-dose CT technique should be strongly considered for certain imaging scenarios, such as the evaluation of nephrolithiasis, where fine detail is not needed, and follow-up studies with known abnormalities, especially in patients younger than 40 years old.

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).

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 & 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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*Practice parameters and technical standards are published annually with an effective date of October 1 in the year in which amended, revised or approved by the ACR Council. For practice parameters and technical standards published before 1999, the effective date was January 1 following the year in which the practice parameter or technical standard was amended, revised, or approved by the ACR Council.

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