Revised 2016 (Resolution 22)*

ACR–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 in light of 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 the condition of the patient, limitations of available resources, or advances in knowledge or technology subsequent to publication of this document. However, a practitioner who employs an approach substantially different from the guidance in this document 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 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 sole purpose of this document is to assist practitioners in achieving this objective.

[1] Iowa 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 revised collaboratively by the American College of Radiology (ACR) and the Society for Pediatric Radiology (SPR).

Computed tomography (CT) is a radiologic modality that utilizes ionizing radiation to obtain cross-sectional images (nonhelical CT) or volumetric data sets (helical CT). The acquired images may also be reprocessed to produce images in many anatomic planes or in 3 dimensions to view entire anatomic volumes. 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.

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 biliary system, including CT cholangiography [41-43]
10. Evaluation of abdominal or pelvic inflammatory processes, including inflammatory bowel disease, infectious bowel disease and its complications, without or with CT enterography [44-48]
11. Assessment of abnormalities of abdominal or pelvic vascular structures [49-52]; noninvasive angiography of the aorta and its branches and noninvasive venography [53-56]
12. Clarification of findings from other imaging studies or laboratory abnormalities
13. Evaluation of known or suspected congenital abnormalities of abdominal or pelvic organs [57-59]
14. Evaluation for bowel obstruction or GI bleeding [60-64]
15. Screening and diagnostic evaluation for colonic polyps and cancers with CT colonography [65-69]
16. Guidance for interventional or therapeutic procedures within the abdomen or pelvis [70-75]
17. Follow-up evaluation after interventional or therapeutic procedures within the abdomen or pelvis, including abscess drainage [76-79]
18. Treatment planning for radiation and chemotherapy and evaluation of tumor response to treatment, including perfusion studies [80-86]
19. Pre- and post-transplant assessment [87-92]

.

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 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 [93] and the ACR Manual on Contrast Media [94]).

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 [95].

III. QUALIFICATIONS AND RESPONSIBILITIES OF PERSONNEL

See the ACR Practice Parameter for Performing and Interpreting Diagnostic Computed Tomography (CT) [96].

IV. SPECIFICATIONS OF THE EXAMINATION

The written or electronic request for a CT of the abdomen and/or a CT of the pelvis 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)

A. In general, a CT examination of the abdomen includes transaxial 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 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 from the task. Protocols should be optimized to give the lowest 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, iterative reconstruction and noise reduction algorithms, and automatic tube voltage selection. 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. Similarly, it may be appropriate for certain tasks, such as evaluating only skeletal structure, to use high-noise/low-dose protocols.

C. In addition to axial images, at least 1 multiplanar reformation, such as coronal images, should be reconstructed if feasible [97-101]. Additionally, sagittal or 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 reformations may be obtained 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 intravenous (IV) contrast medium using appropriate injection techniques [102,103]. 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 lesions such as for possible hepatocellular carcinoma, hypervascular metastases, etc. For specific indications, it may be necessary to perform a non-IV contrast-enhanced study first. Abnormal findings on an unenhanced examination may require further evaluation with contrast enhancement or an alternative imaging study if contrast medium is contraindicated. Administration of IV contrast is generally not required for certain indications such as pure evaluation of bony structures and assessment of urolithiasis.

E. An enteric agent is commonly used in abdominal and pelvis CT scans, but the choice of an enteric agent and type can be determined on a case-by-case basis. 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 contrast material provides improved delineation of abscesses, suspected leaks, intra-abdominal tumors, and tube checks. 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 good visualization of bowel wall hyperenhancement or hypoenhancement. A variety of agents are available. 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 [104]. Neutral enteric contrast may reduce sensitivity for masses or 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 [105].

F. Appropriate window width and level settings should be used to view the visceral organs, the intra-abdominal fat and muscles, the pulmonary parenchyma at the lung bases, and the osseous structures. Particular attention to window width and level settings should be paid when dual energy or low kVp is used.

G. Although many of the settings of a CT scanner are automated, a number of technical parameters remain operator dependent [106]. 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 [107]
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. Field of view
9. Reconstruction algorithm (kernel)

Dual-energy technique may be considered to improve diagnostic confidence, such as to reduce artifacts from metallic objects, improve contrast material conspicuity, confirm the presence of contrast material enhancement in a lesion, and potentially reduce the need for a separate unenhanced CT scan acquisition [108-115]. Low-kVp or dual-energy technique may also be used to reduce the volume of intravenous contrast required.

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.

I. Protocols may be prepared by clinical indication and anatomy to be imaged. Techniques should provide image quality consistent with the diagnostic needs of the examination at appropriate radiation dose levels [111,116-118]. 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 intravenous 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 [118-120].
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 (algorithm)
13. Reconstruction field of view
14. Instructions for which scans/images are sent to PACS (Picture Archiving and Communication System)
15. Three-dimensional and multiplanar reconstructions, (MPR) where needed
16. For every CT examination, the information in the radiation dose report (CTDI 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.

V. DOCUMENTATION

Reporting should be in accordance with the ACR Practice Parameter for Communication of Diagnostic Imaging Findings [121].

VI. EQUIPMENT SPECIFICATIONS

A. Performance Guidelines

To achieve acceptable clinical CT scans of the abdomen and/or pelvis, a CT scanner should meet or exceed the following capabilities:

1. Helical acquisition with a pitch between 0.8 and 2
2. Scan rotation time: ≤1 sec
3. Minimum slice thickness: ≤2 mm
4. Limiting spatial resolution: ≥8 lp/cm for ≥32-cm display field of view (DFOV) and ≥10 lp/cm for <24 cm DFOV

Additional 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) [122].

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 [94].

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.

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 [123-127].
2. Keep the patient's arms above the abdomen [128,129].
3. Remove non-necessary, densely radiopaque objects from the patient.

Use low-dose CT technique for imaging scenarios such as the evaluation of nephrolithiasis, where fine detail is not needed, or when imaging younger patients <40 years old.

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 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).

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 Diagnostic Computed Tomography (CT) [130].

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 [131].

ACKNOWLEDGEMENTS

This practice parameter was revised according to the process described under the heading *The Process for Developing ACR Practice Parameters and Technical Standards* on the ACR website (http://www.acr.org/guidelines) by the Committee on Body Imaging (Abdominal) of the ACR Commission on Body Imaging, and the Committee on Practice Parameters – Pediatric Radiology of the ACR Commission on Pediatric Radiology, in collaboration with the SPR.

Collaborative Committee – members represent their societies in the initial and final revision of this practice parameter

ACR
Benjamin M. Yeh, MD, Chair
Avinash Kambadakone, MD
Ruedi F. Thoeni, MD
Alexander J. Towbin, MD

SPR
Arthur B. Meyers, MD
Ethan A. Smith, MD
Kristen B. Thomas, MD

Committee on Body Imaging (Abdominal)
(ACR Committee responsible for sponsoring the draft through the process)

Ruedi F. Thoeni, MD, Chair
Mahmoud M. Al-Hawary, MD
Mark E. Baker, MD, FACR
Barry D. Daly, MD, MB, BCh
Isaac R. Francis, MD, FACR
Patrick Gonzales, MD
Richard M. Gore, MD, FACR
Dean D. Maglinte, MD, FACR
Frank H. Miller, MD, FACR
Donald G. Mitchell, MD, FACR
Eric M. Rubin, MD
Scott D. Stevens, MD, FACR
William E. Torres, MD, FACR

Committee on Practice Parameters – Pediatric Radiology
(ACR Committee responsible for sponsoring the draft through the process)

Beverley Newman, MB, BCh, BSc, FACR, Chair

Lorna P. Browne, MB, BCh
Timothy J. Carmody, MD, FACR
Brian D. Coley, MD, FACR
Lee K. Collins, MD
Monica S. Epelman, MD
Lynn Ansley Fordham, MD, FACR
Kerri A. Highmore, MD
Sue C. Kaste, DO
Tal Laor, MD
Terry L. Levin, MD
Marguerite T. Parisi, MD, MS
Sumit Pruthi, MBBS
Nancy K. Rollins, MD
Pallavi Sagar, MD

Lincoln L. Berland, MD, FACR, Chair, Commission on Body Imaging
Marta Hernanz-Schulman, MD, FACR, Chair, Commission on Pediatric Imaging
Jacqueline A. Bello, MD, FACR, Chair, Commission on Quality and Safety
Matthew S. Pollack, MD, FACR, Chair, Committee on Practice Parameters and Technical Standards

<u>Comments Reconciliation Committee</u>
Joseph G. Cernigliaro, MD, FACR, Chair
Eric J. Stern, MD, Co-Chair
Jacqueline A. Bello, MD, FACR
Lincoln L. Berland, MD, FACR
Sabina Choudhry, MB, BS
Marta Hernanz-Schulman, MD, FACR
William T. Herrington, MD, FACR
Avinash Kambadakone, MD
Paul A. Larson, MD, FACR
Arthur B. Meyers, MD
Beverley Newman, MB, BCh, BSc, FACR
Matthew S. Pollack, MD, FACR
William F. Sensakovic, BA, BS, PhD
Ethan A. Smith, MD
Timothy L. Swan, MD, FACR
Ruedi F. Thoeni, MD
Kristen B. Thomas, MD
Alexander J. Towbin, MD
Benjamin M. Yeh, MD

REFERENCES

1. Niemann T, Kollmann T, Bongartz G. Diagnostic performance of low-dose CT for the detection of urolithiasis: a meta-analysis. *AJR Am J Roentgenol.* 2008;191(2):396-401.
2. Ciaschini MW, Remer EM, Baker ME, Lieber M, Herts BR. Urinary calculi: radiation dose reduction of 50% and 75% at CT--effect on sensitivity. *Radiology.* 2009;251(1):105-111.
3. Glazer DI, Maturen KE, Cohan RH, et al. Assessment of 1 mSv urinary tract stone CT with model-based iterative reconstruction. *AJR Am J Roentgenol.* 2014;203(6):1230-1235.
4. Krajewski S, Brown J, Phang PT, Raval M, Brown CJ. Impact of computed tomography of the abdomen on clinical outcomes in patients with acute right lower quadrant pain: a meta-analysis. *Can J Surg.* 2011;54(1):43-53.
5. Bendeck SE, Nino-Murcia M, Berry GJ, Jeffrey RB, Jr. Imaging for suspected appendicitis: negative appendectomy and perforation rates. *Radiology.* 2002;225(1):131-136.

6. Keyzer C, Cullus P, Tack D, De Maertelaer V, Bohy P, Gevenois PA. MDCT for suspected acute appendicitis in adults: impact of oral and IV contrast media at standard-dose and simulated low-dose techniques. *AJR Am J Roentgenol.* 2009;193(5):1272-1281.
7. Atri M, Hanson JM, Grinblat L, Brofman N, Chughtai T, Tomlinson G. Surgically important bowel and/or mesenteric injury in blunt trauma: accuracy of multidetector CT for evaluation. *Radiology.* 2008;249(2):524-533.
8. Hamilton JD, Kumaravel M, Censullo ML, Cohen AM, Kievlan DS, West OC. Multidetector CT evaluation of active extravasation in blunt abdominal and pelvic trauma patients. *Radiographics.* 2008;28(6):1603-1616.
9. Murakami AM, Anderson SW, Soto JA, Kertesz JL, Ozonoff A, Rhea JT. Active extravasation of the abdomen and pelvis in trauma using 64MDCT. *Emerg Radiol.* 2009;16(5):375-382.
10. Tillou A, Gupta M, Baraff LJ, et al. Is the use of pan-computed tomography for blunt trauma justified? A prospective evaluation. *J Trauma.* 2009;67(4):779-787.
11. Goodman CS, Hur JY, Adajar MA, Coulam CH. How well does CT predict the need for laparotomy in hemodynamically stable patients with penetrating abdominal injury? A review and meta-analysis. *AJR Am J Roentgenol.* 2009;193(2):432-437.
12. Caoili EM, Cohan RH, Korobkin M, et al. Urinary tract abnormalities: initial experience with multi-detector row CT urography. *Radiology.* 2002;222(2):353-360.
13. Dyer R, DiSantis DJ, McClennan BL. Simplified imaging approach for evaluation of the solid renal mass in adults. *Radiology.* 2008;247(2):331-343.
14. Silverman SG, Leyendecker JR, Amis ES, Jr. What is the current role of CT urography and MR urography in the evaluation of the urinary tract? *Radiology.* 2009;250(2):309-323.
15. Sangwaiya MJ, Boland GW, Cronin CG, Blake MA, Halpern EF, Hahn PF. Incidental adrenal lesions: accuracy of characterization with contrast-enhanced washout multidetector CT--10-minute delayed imaging protocol revisited in a large patient cohort. *Radiology.* 2010;256(2):504-510.
16. Mileto A, Nelson RC, Paulson EK, Marin D. Dual-Energy MDCT for Imaging the Renal Mass. *AJR Am J Roentgenol.* 2015:W1-W8.
17. Hong X, Choi H, Loyer EM, Benjamin RS, Trent JC, Charnsangavej C. Gastrointestinal stromal tumor: role of CT in diagnosis and in response evaluation and surveillance after treatment with imatinib. *Radiographics.* 2006;26(2):481-495.
18. Grabowska-Derlatka L, Derlatka P, Palczewski P, Danska-Bidzinska A, Pacho R. Differentiation of ovarian cancers from borderline ovarian tumors on the basis of evaluation of tumor vascularity in multi-row detector computed tomography--comparison with histopathology. *Int J Gynecol Cancer.* 2013;23(9):1597-1602.
19. Mazzei MA, Khader L, Cirigliano A, et al. Accuracy of MDCT in the preoperative definition of Peritoneal Cancer Index (PCI) in patients with advanced ovarian cancer who underwent peritonectomy and hyperthermic intraperitoneal chemotherapy (HIPEC). *Abdom Imaging.* 2013;38(6):1422-1430.
20. Tsili AC, Tsangou V, Koliopoulos G, Stefos T, Argyropoulou MI. Early-stage cervical carcinoma: the role of multidetector CT in correlation with histopathological findings. *J Obstet Gynaecol.* 2013;33(8):882-887.
21. Kamel IR, Choti MA, Horton KM, et al. Surgically staged focal liver lesions: accuracy and reproducibility of dual-phase helical CT for detection and characterization. *Radiology.* 2003;227(3):752-757.
22. Jang HJ, Kim TK, Khalili K, et al. Characterization of 1-to 2-cm liver nodules detected on hcc surveillance ultrasound according to the criteria of the American Association for the Study of Liver Disease: is quadriphasic CT necessary? *AJR Am J Roentgenol.* 2013;201(2):314-321.
23. Raman SP, Fishman EK. Advances in CT Imaging of GI Malignancies. *Gastrointest Cancer Res.* 2012;5(3 Suppl 1):S4-9.
24. Lee MH, Choi D, Park MJ, Lee MW. Gastric cancer: imaging and staging with MDCT based on the 7th AJCC guidelines. *Abdom Imaging.* 2012;37(4):531-540.
25. Min JH, Lee MW, Rhim H, et al. Local tumour progression after loco-regional therapy of hepatocellular carcinomas: value of fusion imaging-guided radiofrequency ablation. *Clin Radiol.* 2014;69(3):286-293.

26. Wah TM, Irving HC, Gregory W, Cartledge J, Joyce AD, Selby PJ. Radiofrequency ablation (RFA) of renal cell carcinoma (RCC): experience in 200 tumours. *BJU Int.* 2014;113(3):416-428.
27. Dollinger M, Jung EM, Beyer L, et al. Irreversible electroporation ablation of malignant hepatic tumors: subacute and follow-up CT appearance of ablation zones. *J Vasc Interv Radiol.* 2014;25(10):1589-1594.
28. Mazioti A, Gatselis NK, Rountas C, et al. Safety and efficacy of transcatheter arterial chemoemboliazation in the real-life management of unresectable hepatocellular carcinoma. *Hepat Mon.* 2013;13(8):e7070.
29. Kim JY, Kim SH, Lee HJ, Kim MJ, Kim YH, Cho SH. MDCT urography for detecting recurrence after transurethral resection of bladder cancer: comparison of nephrographic phase with pyelographic phase. *AJR Am J Roentgenol.* 2014;203(5):1021-1027.
30. Kim KW, Choi BI, Han JK, et al. Postoperative anatomic and pathologic findings at CT following gastrectomy. *Radiographics.* 2002;22(2):323-336.
31. Pannu HK, Bristow RE, Montz FJ, Fishman EK. Multidetector CT of peritoneal carcinomatosis from ovarian cancer. *Radiographics.* 2003;23(3):687-701.
32. Aguirre DA, Santosa AC, Casola G, Sirlin CB. Abdominal wall hernias: imaging features, complications, and diagnostic pitfalls at multi-detector row CT. *Radiographics.* 2005;25(6):1501-1520.
33. Blachar A, Federle MP, Pealer KM, Ikramuddin S, Schauer PR. Gastrointestinal complications of laparoscopic Roux-en-Y gastric bypass surgery: clinical and imaging findings. *Radiology.* 2002;223(3):625-632.
34. Pickhardt PJ, Bhalla S, Balfe DM. Acquired gastrointestinal fistulas: classification, etiologies, and imaging evaluation. *Radiology.* 2002;224(1):9-23.
35. Yu J, Turner MA, Cho SR, et al. Normal anatomy and complications after gastric bypass surgery: helical CT findings. *Radiology.* 2004;231(3):753-760.
36. Catala V, Sola M, Samaniego J, et al. CT findings in urinary diversion after radical cystectomy: postsurgical anatomy and complications. *Radiographics.* 2009;29(2):461-476.
37. Bandula S, Punwani S, Rosenberg WM, et al. Equilibrium contrast-enhanced CT imaging to evaluate hepatic fibrosis: initial validation by comparison with histopathologic sampling. *Radiology.* 2015;275(1):136-143.
38. Zissen MH, Wang ZJ, Yee J, Aslam R, Monto A, Yeh BM. Contrast-enhanced CT quantification of the hepatic fractional extracellular space: correlation with diffuse liver disease severity. *AJR Am J Roentgenol.* 2013;201(6):1204-1210.
39. Kim DY, Park SH, Lee SS, et al. Contrast-enhanced computed tomography for the diagnosis of fatty liver: prospective study with same-day biopsy used as the reference standard. *Eur Radiol.* 2010;20(2):359-366.
40. Miller WJ, Baron RL, Dodd GD, 3rd, Federle MP. Malignancies in patients with cirrhosis: CT sensitivity and specificity in 200 consecutive transplant patients. *Radiology.* 1994;193(3):645-650.
41. Wang ZJ, Yeh BM, Roberts JP, Breiman RS, Qayyum A, Coakley FV. Living donor candidates for right hepatic lobe transplantation: evaluation at CT cholangiography--initial experience. *Radiology.* 2005;235(3):899-904.
42. Ajiki T, Fukumoto T, Ueno K, Okazaki T, Matsumoto I, Ku Y. Three-dimensional computed tomographic cholangiography as a novel diagnostic tool for evaluation of bile duct invasion of perihilar cholangiocarcinoma. *Hepatogastroenterology.* 2013;60(128):1833-1838.
43. Fidler JL, Knudsen JM, Collins DA, et al. Prospective assessment of dynamic CT and MR cholangiography in functional biliary pain. *AJR Am J Roentgenol.* 2013;201(2):W271-282.
44. Guimaraes LS, Fidler JL, Fletcher JG, et al. Assessment of appropriateness of indications for CT enterography in younger patients. *Inflamm Bowel Dis.* 2010;16(2):226-232.
45. 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 Am J Roentgenol.* 2008;190(6):1512-1516.
46. 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 Am J Roentgenol.* 2011;196(6):W743-752.
47. 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(3):744-751.

48. 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*. 2015:140468.
49. De Cecco CN, Ferrari R, Rengo M, Paolantonio P, Vecchietti F, Laghi A. Anatomic variations of the hepatic arteries in 250 patients studied with 64-row CT angiography. *Eur Radiol*. 2009;19(11):2765-2770.
50. Turkvatan A, Ozdemir M, Cumhur T, Olcer T. Multidetector CT angiography of renal vasculature: normal anatomy and variants. *Eur Radiol*. 2009;19(1):236-244.
51. Vu M, Anderson SW, Shah N, Soto JA, Rhea JT. CT of blunt abdominal and pelvic vascular injury. *Emerg Radiol*. 2010;17(1):21-29.
52. Fuentes-Orrego JM, Pinho D, Kulkarni NM, Agrawal M, Ghoshhajra BB, Sahani DV. New and evolving concepts in CT for abdominal vascular imaging. *Radiographics*. 2014;34(5):1363-1384.
53. Heijenbrok-Kal MH, Kock MC, Hunink MG. Lower extremity arterial disease: multidetector CT angiography meta-analysis. *Radiology*. 2007;245(2):433-439.
54. Rubin GD, Armerding MD, Dake MD, Napel S. Cost identification of abdominal aortic aneurysm imaging by using time and motion analyses. *Radiology*. 2000;215(1):63-70.
55. Ippolito D, Talei Franzesi C, Fior D, Bonaffini PA, Minutolo O, Sironi S. Low kV settings CT angiography (CTA) with low dose contrast medium volume protocol in the assessment of thoracic and abdominal aorta disease: a feasibility study. *Br J Radiol*. 2015;88(1049):20140140.
56. Liu PS, Platt JF. CT angiography in the abdomen: a pictorial review and update. *Abdom Imaging*. 2014;39(1):196-214.
57. Suzuki K, Nishimi D, Morioka H, Takanami M. Hematospermia associated with congenital arteriovenous malformation of internal iliac vessels. *Int J Urol*. 2007;14(4):370-372.
58. Zeitoun D, Brancatelli G, Colombat M, et al. Congenital hepatic fibrosis: CT findings in 18 adults. *Radiology*. 2004;231(1):109-116.
59. Lawler LP, Jarret TW, Corl FM, Fishman EK. Adult ureteropelvic junction obstruction: insights with three-dimensional multi-detector row CT. *Radiographics*. 2005;25(1):121-134.
60. Delabrousse E, Lubrano J, Jehl J, et al. Small-bowel obstruction from adhesive bands and matted adhesions: CT differentiation. *AJR Am J Roentgenol*. 2009;192(3):693-697.
61. Sundaram B, Miller CN, Cohan RH, Schipper MJ, Francis IR. Can CT features be used to diagnose surgical adult bowel intussusceptions? *AJR Am J Roentgenol*. 2009;193(2):471-478.
62. Artigas JM, Marti M, Soto JA, Esteban H, Pinilla I, Guillen E. Multidetector CT angiography for acute gastrointestinal bleeding: technique and findings. *Radiographics*. 2013;33(5):1453-1470.
63. Wang Z, Chen JQ, Liu JL, Qin XG, Huang Y. CT enterography in obscure gastrointestinal bleeding: a systematic review and meta-analysis. *J Med Imaging Radiat Oncol*. 2013;57(3):263-273.
64. Boudiaf M, Soyer P, Terem C, Pelage JP, Maissiat E, Rymer R. Ct evaluation of small bowel obstruction. *Radiographics*. 2001;21(3):613-624.
65. Johnson CD. CT colonography: coming of age. *AJR Am J Roentgenol*. 2009;193(5):1239-1242.
66. Plumb AA, Halligan S, Pendse DA, Taylor SA, Mallett S. Sensitivity and specificity of CT colonography for the detection of colonic neoplasia after positive faecal occult blood testing: systematic review and meta-analysis. *Eur Radiol*. 2014;24(5):1049-1058.
67. Kriza C, Emmert M, Wahlster P, Niederlander C, Kolominsky-Rabas P. An international review of the main cost-effectiveness drivers of virtual colonography versus conventional colonoscopy for colorectal cancer screening: is the tide changing due to adherence? *Eur J Radiol*. 2013;82(11):e629-636.
68. Pickhardt PJ, Hassan C, Halligan S, Marmo R. Colorectal cancer: CT colonography and colonoscopy for detection--systematic review and meta-analysis. *Radiology*. 2011;259(2):393-405.
69. American College of Radiology. ACR–SAR–SCBT-MR practice parameter for the performance of computed tomography (CT) colonography in adults. 2014; Available at: https://www.acr.org/-/media/ACR/Files/Practice-Parameters/CT-Colonog.pdf. Accessed May 21, 2015.
70. Gervais DA, Brown SD, Connolly SA, Brec SL, Harisinghani MG, Mueller PR. Percutaneous imaging-guided abdominal and pelvic abscess drainage in children. *Radiographics*. 2004;24(3):737-754.
71. Singh B, May K, Coltart I, Moore NR, Cunningham C. The long-term results of percutaneous drainage of diverticular abscess. *Ann R Coll Surg Engl*. 2008;90(4):297-301.

72. Stattaus J, Kalkmann J, Kuehl H, et al. Diagnostic yield of computed tomography-guided coaxial core biopsy of undetermined masses in the free retroperitoneal space: single-center experience. *Cardiovasc Intervent Radiol.* 2008;31(5):919-925.
73. Cronin CG, Gervais DA, Hahn PF, Arellano R, Guimaraes AR, Mueller PR. Treatment of deep intramuscular and musculoskeletal abscess: experience with 99 CT-guided percutaneous catheter drainage procedures. *AJR Am J Roentgenol.* 2011;196(5):1182-1188.
74. Yamakado K, Takaki H, Nakatsuka A, et al. Percutaneous transhepatic drainage of inaccessible abdominal abscesses following abdominal surgery under real-time CT-fluoroscopic guidance. *Cardiovasc Intervent Radiol.* 2010;33(1):161-163.
75. Heilbrun ME, Zagoria RJ, Garvin AJ, et al. CT-guided biopsy for the diagnosis of renal tumors before treatment with percutaneous ablation. *AJR Am J Roentgenol.* 2007;188(6):1500-1505.
76. Liao WI, Tsai SH, Yu CY, et al. Pyogenic liver abscess treated by percutaneous catheter drainage: MDCT measurement for treatment outcome. *Eur J Radiol.* 2012;81(4):609-615.
77. Shin S, Lee JM, Kim KW, et al. Postablation assessment using follow-up registration of CT images before and after radiofrequency ablation (RFA): prospective evaluation of midterm therapeutic results of RFA for hepatocellular carcinoma. *AJR Am J Roentgenol.* 2014;203(1):70-77.
78. Schima W, Ba-Ssalamah A, Kurtaran A, Schindl M, Gruenberger T. Post-treatment imaging of liver tumours. *Cancer Imaging.* 2007;7 Spec No A:S28-36.
79. Park MH, Rhim H, Kim YS, Choi D, Lim HK, Lee WJ. Spectrum of CT findings after radiofrequency ablation of hepatic tumors. *Radiographics.* 2008;28(2):379-390; discussion 390-372.
80. Kawamoto S, Permpongkosol S, Bluemke DA, Fishman EK, Solomon SB. Sequential changes after radiofrequency ablation and cryoablation of renal neoplasms: role of CT and MR imaging. *Radiographics.* 2007;27(2):343-355.
81. Meijerink MR, van Cruijsen H, Hoekman K, et al. The use of perfusion CT for the evaluation of therapy combining AZD2171 with gefitinib in cancer patients. *Eur Radiol.* 2007;17(7):1700-1713.
82. Schlemmer M, Sourbron SP, Schinwald N, et al. Perfusion patterns of metastatic gastrointestinal stromal tumor lesions under specific molecular therapy. *Eur J Radiol.* 2011;77(2):312-318.
83. Jang GS, Kim MJ, Ha HI, et al. Comparison of RECIST version 1.0 and 1.1 in assessment of tumor response by computed tomography in advanced gastric cancer. *Chin J Cancer Res.* 2013;25(6):689-694.
84. Schramm N, Englhart E, Schlemmer M, et al. Tumor response and clinical outcome in metastatic gastrointestinal stromal tumors under sunitinib therapy: comparison of RECIST, Choi and volumetric criteria. *Eur J Radiol.* 2013;82(6):951-958.
85. Kim SH, Kamaya A, Willmann JK. CT perfusion of the liver: principles and applications in oncology. *Radiology.* 2014;272(2):322-344.
86. Viswanathan C, Truong MT, Sagebiel TL, et al. Abdominal and pelvic complications of nonoperative oncologic therapy. *Radiographics.* 2014;34(4):941-961.
87. Hermoye L, Laamari-Azjal I, Cao Z, et al. Liver segmentation in living liver transplant donors: comparison of semiautomatic and manual methods. *Radiology.* 2005;234(1):171-178.
88. Peterson MS, Baron RL, Marsh JW, Jr., Oliver JH, 3rd, Confer SR, Hunt LE. Pretransplantation surveillance for possible hepatocellular carcinoma in patients with cirrhosis: epidemiology and CT-based tumor detection rate in 430 cases with surgical pathologic correlation. *Radiology.* 2000;217(3):743-749.
89. Sahani DV, Rastogi N, Greenfield AC, et al. Multi-detector row CT in evaluation of 94 living renal donors by readers with varied experience. *Radiology.* 2005;235(3):905-910.
90. Zamboni GA, Romero JY, Raptopoulos VD. Combined vascular-excretory phase MDCT angiography in the preoperative evaluation of renal donors. *AJR Am J Roentgenol.* 2010;194(1):145-150.
91. Kawamoto S, Montgomery RA, Lawler LP, Horton KM, Fishman EK. Multi-detector row CT evaluation of living renal donors prior to laparoscopic nephrectomy. *Radiographics.* 2004;24(2):453-466.
92. Singh AK, Nachiappan AC, Verma HA, et al. Postoperative imaging in liver transplantation: what radiologists should know. *Radiographics.* 2010;30(2):339-351.
93. American College of Radiology. ACR–SPR practice parameter for the use of intravascular contrast media. 2012; Available at: https://www.acr.org/-/media/ACR/Files/Practice-Parameters/IVCM.pdf. Accessed January 22, 2015.
94. American College of Radiology. ACR manual on contrast media, version 9. 2013; Available at: http://www.acr.org/Quality-Safety/Resources/Contrast-Manual. Accessed January 22, 2015.

95. American College of Radiology. ACR–SPR practice parameter for imaging pregnant or potentially pregnant adolescents and women with ionizing radiation. 2013; Available at: https://www.acr.org/-/media/ACR/Files/Practice-Parameters/Pregnant-Pts.pdf. Accessed January 22, 2015.
96. American College of Radiology. ACR practice parameter for performing and interpreting computed tomography (CT). 2011; Available at: https://www.acr.org/-/media/ACR/Files/Practice-Parameters/CT-Perf-Interpret.pdf. Accessed January 22, 2015.
97. Tsili AC, Argyropoulou MI, Gousia A, et al. Renal cell carcinoma: value of multiphase MDCT with multiplanar reformations in the detection of pseudocapsule. *AJR Am J Roentgenol.* 2012;199(2):379-386.
98. Yun BL, Kim SH, Kim SJ, et al. Added value of multiplanar reformations to axial multi-detector row computed tomographic images for the differentiation of macrocystic pancreas neoplasms: receiver operating characteristic analysis. *J Comput Assist Tomogr.* 2010;34(6):899-906.
99. Neville AM, Paulson EK. MDCT of acute appendicitis: value of coronal reformations. *Abdom Imaging.* 2009;34(1):42-48.
100. Sandrasegaran K, Rydberg J, Tann M, Hawes DR, Kopecky KK, Maglinte DD. Benefits of routine use of coronal and sagittal reformations in multi-slice CT examination of the abdomen and pelvis. *Clin Radiol.* 2007;62(4):340-347.
101. Jaffe TA, Martin LC, Thomas J, Adamson AR, DeLong DM, Paulson EK. Small-bowel obstruction: coronal reformations from isotropic voxels at 16-section multi-detector row CT. *Radiology.* 2006;238(1):135-142.
102. Tschugunow A, Puesken M, Juergens KU, et al. Optimization of scan delay for routine abdominal 64-slice CT with body weight-adapted application of contrast material. *Rofo.* 2009;181(7):683-690.
103. Yamashita Y, Komohara Y, Takahashi M, et al. Abdominal helical CT: evaluation of optimal doses of intravenous contrast material--a prospective randomized study. *Radiology.* 2000;216(3):718-723.
104. Baker ME, Hara AK, Platt JF, Maglinte DD, Fletcher JG. CT enterography for Crohn's disease: optimal technique and imaging issues. *Abdom Imaging.* 2015.
105. Cansu A, Ahmetoglu A, Kul S, et al. Diagnostic performance of using effervescent powder for detection and grading of esophageal varices by multi-detector computed tomography. *Eur J Radiol.* 2014;83(3):497-502.
106. Flohr TG, Schaller S, Stierstorfer K, Bruder H, Ohnesorge BM, Schoepf UJ. Multi-detector row CT systems and image-reconstruction techniques. *Radiology.* 2005;235(3):756-773.
107. Ehman EC, Yu L, Manduca A, et al. Methods for clinical evaluation of noise reduction techniques in abdominopelvic CT. *Radiographics.* 2014;34(4):849-862.
108. Silva AC, Morse BG, Hara AK, Paden RG, Hongo N, Pavlicek W. Dual-energy (spectral) CT: applications in abdominal imaging. *Radiographics.* 2011;31(4):1031-1046; discussion 1047-1050.
109. Karcaaltincaba M, Ozdeniz I. Dual-energy CT for diagnostic CT colonography. *Radiographics.* 2014;34(3):847.
110. Agrawal MD, Pinho DF, Kulkarni NM, Hahn PF, Guimaraes AR, Sahani DV. Oncologic applications of dual-energy CT in the abdomen. *Radiographics.* 2014;34(3):589-612.
111. Kaza RK, Platt JF, Cohan RH, Caoili EM, Al-Hawary MM, Wasnik A. Dual-energy CT with single- and dual-source scanners: current applications in evaluating the genitourinary tract. *Radiographics.* 2012;32(2):353-369.
112. Mileto A, Nelson RC, Marin D, Roy Choudhury K, Ho LM. Dual-energy multidetector CT for the characterization of incidental adrenal nodules: diagnostic performance of contrast-enhanced material density analysis. *Radiology.* 2015;274(2):445-454.
113. Clark ZE, Bolus DN, Little MD, Morgan DE. Abdominal rapid-kVp-switching dual-energy MDCT with reduced IV contrast compared to conventional MDCT with standard weight-based IV contrast: an intra-patient comparison. *Abdom Imaging.* 2015;40(4):852-858.
114. Han SC, Chung YE, Lee YH, Park KK, Kim MJ, Kim KW. Metal artifact reduction software used with abdominopelvic dual-energy CT of patients with metal hip prostheses: assessment of image quality and clinical feasibility. *AJR Am J Roentgenol.* 2014;203(4):788-795.
115. Jepperson MA, Cernigliaro JG, Ibrahim el SH, Morin RL, Haley WE, Thiel DD. In vivo comparison of radiation exposure of dual-energy CT versus low-dose CT versus standard CT for imaging urinary calculi. *J Endourol.* 2015;29(2):141-146.

116. Tamm EP, Rong XJ, Cody DD, Ernst RD, Fitzgerald NE, Kundra V. Quality initiatives: CT radiation dose reduction: how to implement change without sacrificing diagnostic quality. *Radiographics.* 2011;31(7):1823-1832.
117. Yu L, Bruesewitz MR, Thomas KB, Fletcher JG, Kofler JM, McCollough CH. Optimal tube potential for radiation dose reduction in pediatric CT: principles, clinical implementations, and pitfalls. *Radiographics.* 2011;31(3):835-848.
118. Lee CH, Goo JM, Ye HJ, et al. Radiation dose modulation techniques in the multidetector CT era: from basics to practice. *Radiographics.* 2008;28(5):1451-1459.
119. Goshima S, Kanematsu M, Kondo H, et al. MDCT of the liver and hypervascular hepatocellular carcinomas: optimizing scan delays for bolus-tracking techniques of hepatic arterial and portal venous phases. *AJR Am J Roentgenol.* 2006;187(1):W25-32.
120. Kondo H, Kanematsu M, Goshima S, et al. MDCT of the pancreas: optimizing scanning delay with a bolus-tracking technique for pancreatic, peripancreatic vascular, and hepatic contrast enhancement. *AJR Am J Roentgenol.* 2007;188(3):751-756.
121. American College of Radiology. ACR practice parameter for communication of diagnostic imaging findings. 2014; Available at: https://www.acr.org/-/media/ACR/Files/Practice-Parameters/CommunicationDiag.pdf. Accessed January 22, 2015.
122. American College of Radiology. ACR-ASER-SCBT-MR-SPR practice parameter for the performance of pediatric computed tomography (CT). 2014; Available at: https://www.acr.org/-/media/ACR/Files/Practice-Parameters/CT-Ped.pdf. Accessed June 16, 2015.
123. Harri PA, Moreno CC, Nelson RC, et al. Variability of MDCT dose due to technologist performance: impact of posteroanterior versus anteroposterior localizer image and table height with use of automated tube current modulation. *AJR Am J Roentgenol.* 2014;203(2):377-386.
124. Habibzadeh MA, Ay MR, Asl AR, Ghadiri H, Zaidi H. Impact of miscentering on patient dose and image noise in x-ray CT imaging: phantom and clinical studies. *Phys Med.* 2012;28(3):191-199.
125. Schindera ST, Nauer C, Treier R, et al. [Strategies for reducing the CT radiation dose]. *Radiologe.* 2010;50(12):1120, 1122-1127.
126. Gudjonsdottir J, Svensson JR, Campling S, Brennan PC, Jonsdottir B. Efficient use of automatic exposure control systems in computed tomography requires correct patient positioning. *Acta Radiol.* 2009;50(9):1035-1041.
127. Li J, Udayasankar UK, Toth TL, Seamans J, Small WC, Kalra MK. Automatic patient centering for MDCT: effect on radiation dose. *AJR Am J Roentgenol.* 2007;188(2):547-552.
128. Liu H, Gao Y, Ding A, Caracappa PF, Xu XG. The profound effects of patient arm positioning on organ doses from CT procedures calculated using Monte Carlo simulations and deformable phantoms. *Radiat Prot Dosimetry.* 2015;164(3):368-375.
129. Brink M, de Lange F, Oostveen LJ, et al. Arm raising at exposure-controlled multidetector trauma CT of thoracoabdominal region: higher image quality, lower radiation dose. *Radiology.* 2008;249(2):661-670.
130. American College of Radiology. ACR practice parameter for performing and interpreting diagnostic computed tomography (CT). 2011; Available at: https://www.acr.org/-/media/ACR/Files/Practice-Parameters/CT-Perf-Interpret.pdf. Accessed January 22, 2015.
131. American College of Radiology. ACR–AAPM technical standard for diagnostic medical physics performance monitoring of computed tomography (CT) equipment. 2012; Available at: https://www.acr.org/-/media/ACR/Files/Practice-Parameters/CT-Equip.pdf. Accessed January 22, 2015.

---

*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.

<u>Development Chronology for This Practice Parameter</u>
1995 (Resolution 2)
Amended 1996 (Resolution 24, 53)
Revised 1997 (Resolution 31)
Revised 2001 (Resolution 8)
Revised 2006 (Resolution 13, 17, 35)

Amended 2009 (Resolution 11)
Revised 2011 (Resolution 32)
Amended 2014 (Resolution 39)
Revised 2016 (Resolution 22)