ACR–AIUM–SPR–SRU PRACTICE PARAMETER FOR THE PERFORMANCE OF AN ULTRASOUND EXAMINATION OF THE ABDOMEN AND/OR RETROPERITONEUM

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The American College of Radiology will periodically define new practice parameters and technical standards for radiologic practice to help advance the science of radiology and to improve the quality of service to patients throughout the United States. Existing practice parameters and technical standards will be reviewed for revision or renewal, as appropriate, on their fifth anniversary or sooner, if indicated.

Each practice parameter and technical standard, representing a policy statement by the College, has undergone a thorough consensus process in which it has been subjected to extensive review and approval. The practice parameters and technical standards recognize that the safe and effective use of diagnostic and therapeutic radiology requires specific training, skills, and techniques, as described in each document. Reproduction or modification of the published practice parameter and technical standard by those entities not providing these services is not authorized.

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

The clinical aspects contained in specific sections of this practice parameter (Introduction, Indications, Specifications of the Examination, and Equipment Specifications) were developed collaboratively by the American College of Radiology (ACR), the American Institute of Ultrasound in Medicine (AIUM), the Society for Pediatric Radiology (SPR), and the Society of Radiologists in Ultrasound (SRU). Recommendations for physician requirements, written request for the examination, procedure documentation, and quality control vary among the organizations and are addressed by each separately.

This practice parameter has been revised to assist practitioners performing ultrasound studies of the abdomen and/or retroperitoneum. Sonography is a proven and useful procedure for evaluating the many structures within these anatomic areas. Depending on the clinical indications, an examination may include the entirety of the abdomen and/or retroperitoneum, a single organ, or several organs. A combination of structures may be imaged because of location (eg, upper abdominal scan, right upper quadrant organs) or function (eg, biliary system [liver, gallbladder, and bile ducts], both kidneys). For some patients, more focused examinations may be appropriate for evaluating specific clinical indications or to follow up a known abnormality. In some cases, additional and/or specialized examinations may be necessary (eg, spectral, color, and/or power Doppler, elastography, or contrast-enhanced ultrasound (CEUS)). Although it is not possible to detect every abnormality using ultrasound examination of the abdomen and/or retroperitoneum, adherence to the following practice parameter will maximize the probability of detecting abnormalities.
Throughout this practice parameter, references to Doppler evaluation may include spectral, color, or power Doppler individually or in any combination. Whenever a long-axis view is indicated, it could be either a sagittal or coronal plane image.

II. INDICATIONS AND CONTRAINDICATIONS

Indications for ultrasound examination of the abdomen and/or retroperitoneum include, but are not limited to [1]:

1. Abdominal, flank, and/or back pain
2. Signs or symptoms that may be referred from the abdominal and/or retroperitoneal regions, such as jaundice or hematuria
3. Palpable abnormalities, such as an abdominal mass or organomegaly
4. Abnormal laboratory values
5. Abnormal findings on other imaging examinations suggestive of abdominal and/or retroperitoneal pathology that require further characterization; and follow-up of known or suspected abnormalities in the abdomen and/or retroperitoneum
6. Assessment of diseases of the biliary system and pancreas, including gallstones, cholecystitis, gallbladder dysfunction, biliary atresia, choledochal cyst, choledocholithiasis, pancreatitis, pseudocysts, pancreatic anomalies and pancreatic neoplasms
7. Search for metastatic disease or occult primary neoplasm complementing other cross-sectional imaging
8. Search for source of fever, infection
9. Evaluation of cirrhosis, portal hypertension, and transjugular intrahepatic portosystemic shunt (TIPS) stents; screening for hepatoma; evaluation of the liver in conjunction with liver elastography
10. Abdominal trauma
11. Evaluation of urinary tract pathology including, but not limited to, urinary tract dilation, stone disease, sequelae of infection, and postvoid residual
12. Evaluation of hypertension and suspected renal artery stenosis
13. Search for the presence of free or loculated peritoneal and/or retroperitoneal fluid
14. Evaluation of suspected congenital abnormalities
15. Evaluation of suspected hypertrophic pyloric stenosis, malrotation, and/or midgut volvulus, intussusception, necrotizing inflammatory bowel disease, appendicitis, typhlitis, as well as other bowel abnormalities
16. Pretransplant and posttransplant evaluation
17. Planning for and guiding an invasive procedure
18. Lesion characterization using CEUS [2]

Abdominal and/or retroperitoneal ultrasound should be performed when there is a valid medical reason. There are no absolute contraindications.

III. QUALIFICATIONS AND RESPONSIBILITIES OF PERSONNEL

See the ACR–SPR–SRU Practice Parameter for the Performance and Interpretation of Diagnostic Ultrasound Examinations [3].

IV. WRITTEN REQUEST FOR THE EXAMINATION

The written or electronic request for an abdomen and/or retroperitoneum ultrasound 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)

V. SPECIFICATIONS FOR INDIVIDUAL EXAMINATIONS

1. Liver

The examination of the liver should include long-axis and transverse views. Liver measurement may be performed on longitudinal images at the midclavicular line. The liver parenchyma should be evaluated for focal and/or diffuse abnormalities. If possible, the echogenicity of the liver should be compared with that of the right kidney. In addition, the following should be imaged [4-9]:

a. The major hepatic and perihepatic vessels, including the inferior vena cava (IVC), the hepatic veins, and the portal vein
b. The hepatic lobes (right, left, and caudate) and, if possible, the right hemidiaphragm and the adjacent pleural space
c. The liver surface may be imaged with a high-frequency transducer to evaluate for surface nodularity in patients at risk for cirrhosis
d. For vascular examinations, color and spectral Doppler evaluation should be used to document blood flow characteristics and blood flow direction. The structures that may be examined include the main and intrahepatic arteries, hepatic veins, main and intrahepatic portal veins, intrahepatic portion of the IVC, collateral venous pathways, and TIPS stents. Transplant liver evaluation is covered in detail in the ACR–AIUM–SPR–SRU Practice Parameter for the Performance of an Ultrasound Examination of Solid Organ Transplants [10]. Additionally, in patients predisposed to or suspected of having hepatic fibrosis, hepatic elastography may be performed [11].
e. For patients at risk of hepatocellular carcinoma, recording of transverse and longitudinal cine loops through the right and left lobes may help ensure complete parenchymal visualization and improve sensitivity for detection focal lesions [12]
f. CEUS may be added for the definitive characterization of focal liver lesions or assessment of the hepatic vasculature [13,14]

2. Gallbladder and biliary tract

Routine gallbladder examination should be conducted on an adequately distended gallbladder whenever possible. In most cases, fasting for at least 4 hours prior to elective examination will permit adequate distension of a normally functioning gallbladder. For infants and children, the fasting period should be age appropriate. The gallbladder evaluation should include long-axis and transverse views obtained in the supine position. Decubitus imaging should be performed when feasible. Other positions, such as erect or prone imaging, may be helpful to evaluate the gallbladder and its surrounding areas completely and to differentiate mobile gallstones from impacted gallstones. Measurements in longitudinal and/or transverse planes may aid in determining gallbladder wall thickening. In adults, wall thickness of greater than 3 mm is abnormal. If the patient presents with pain, tenderness to transducer compression over the gallbladder should be assessed (eg, a sonographic Murphy sign).
The intrahepatic bile ducts may be evaluated by obtaining views of the liver demonstrating the right and left branches of the portal vein. Doppler may be used to differentiate hepatic arteries and portal veins from bile ducts. The intrahepatic and extrahepatic bile ducts should be evaluated for dilatation, wall thickening, intraluminal findings, and other abnormalities. The common hepatic duct in the porta hepatis should be measured from inner wall to inner wall and documented; when possible, the common bile duct should be evaluated to its most caudal extent [15-18].

3. Pancreas

Whenever possible, all portions of the pancreas—head, uncinate process, body, and tail—should be identified. Orally administered water and changes in patient positioning or patient's maneuvers, such as upright or decubitus positions, may afford better visualization of the pancreas. The following should be assessed in the examination of the pancreas [18-21]:

a. Parenchymal abnormalities, such as masses and calcifications
b. The distal common bile duct in the region of the pancreatic head
c. The main pancreatic duct for dilatation and any other abnormalities, with dilatation confirmed by measurement
d. The peripancreatic region for adenopathy or collections

4. Spleen

Representative views of the spleen in long-axis and transverse planes should be obtained. Splenic length measurement and/or volume [22] may be helpful in assessing enlargement. Echogenicity of the left kidney should be compared with splenic echogenicity when possible. An attempt should be made to demonstrate the left hemidiaphragm and the adjacent pleural space [23-26]. Patency of the splenic hilar vasculature may be assessed with Doppler interrogation.

5. Bowel

When there is concern for bowel pathology, the bowel may be evaluated for wall thickening, dilatation, muscular hypertrophy, masses, vascularity, adjacent inflammation or fluid collections, and other abnormalities. In the pediatric population, sonography of the pylorus and/or the superior mesenteric artery/vein (SMA/SMV) may be helpful in the assessment of the vomiting infant. Graded compression sonography aids in the visualization of the appendix and other bowel loops. Doppler interrogation, evaluation of bowel-wall thickening, as well as CEUS, may be helpful in the assessment of infection or inflammation of the bowel [27-41]. Use of a high-frequency linear transducer allows for optimal depiction of the bowel wall.

6. Peritoneal fluid

Evaluation for free or loculated peritoneal fluid should include documentation of the extent and location of any fluid identified. Assessment for ascites should include limited images of the pelvis as well as both lower quadrants/paracolic gutters. Fluid localization for subsequent paracentesis can be performed by identifying an appropriate location.
In the setting of trauma, particularly blunt trauma, the examination known as focused assessment with sonography for trauma (FAST) assessment, or focused abdominal sonographic examination for trauma, may be performed [42]. The objective of the abdominal portion of the FAST examination is to screen the abdomen for free fluid. Longitudinal and transverse plane images should be obtained in the right upper quadrant through the area of the liver, left upper quadrant through the area of the spleen, along the bilateral paracolic gutters, and within the pelvis to assess for free fluid. Analysis through a fluid-filled bladder (which may be filled through a catheter, when necessary) may help in the evaluation of the pelvis. The FAST examination also includes assessment of intrathoracic structures outside of the scope of this document.

7. Abdominal wall

When there are signs or symptoms referable to the abdominal wall, an ultrasound examination may be performed to evaluate for hernia, masses, fluid collections, or other abnormalities. The examination should include images of the abdominal wall in the location of symptoms or signs and often necessitates scanning with a high-frequency, high-resolution transducer. The relationship of any identified mass to the peritoneum should be demonstrated. Any defect in the peritoneum and abdominal wall musculature should be documented. The presence or absence of bowel, fluid, organs, or other tissues contained within any abdominal wall defect should be noted. Valsalva maneuvers in supine and upright positioning may be

helpful in hernia detection and determining reducibility. The inferior epigastric vessels are an important anatomic landmark in hernia characterization [43]. Doppler examination may be useful to evaluate for vascular flow in an abdominal mass. Cine clip images can be useful to further define abdominal wall hernias.

8. Kidneys

A complete examination of the kidneys need not be performed with every abdominal examination that may be targeted to other specific abdominal sites. When a complete examination of the kidneys is done, this examination should include long-axis and transverse views of the kidneys. A maximum measurement of renal length should be recorded for both kidneys. Decubitus, prone, or upright positioning may provide better images of the kidneys. When possible, renal echogenicity should be compared with the adjacent liver or spleen. Renal cortical thickness should be assessed [44]. The kidneys, specifically the renal cortices, sinuses, and pelves, as well as the perirenal regions, should be assessed for abnormalities including collecting system dilatation, calculi, masses, and other abnormalities [7,45-52]. CEUS may be helpful in evaluating suspected focal renal lesions [53,54]. Color Doppler imaging may be helpful in detecting calculi via the twinkling artifact [55,56].
For vascular examination of the kidneys, Doppler may be used:

a. To assess renal vasculature, please refer to the ACR-AIUM-SPR-SRU Practice Parameter for the Performance of Duplex Sonography of Native Renal Vessels [57].
b. In the setting of renal transplant, Doppler and 2-D grayscale imaging may be used; please refer to the ACR–AIUM–SPR–SRU Practice Parameter for the Performance of an Ultrasound Examination of Solid Organ Transplants [10].
c. CEUS may be helpful for vascular examinations of the transplanted kidney(s); please refer to the ACR–AIUM–SPR–SRU Practice Parameter for the Performance of an Ultrasound Examination of Solid Organ Transplants [10].

9. Urinary bladder and adjacent structures

When performing a complete ultrasound evaluation of the urinary tract, transverse and longitudinal images of the distended urinary bladder and its wall should be included, if possible. Bladder lumen or wall abnormalities should be noted. Dilatation or other distal ureteral abnormalities should be documented. The acquisition of ureteral jets with color Doppler imaging may be helpful when evaluating hydroureteronephrosis to evaluate for the presence of obstruction. Transvaginal ultrasound may also be a helpful tool in evaluating distal ureteral calculi in women [58]. Transverse and longitudinal scans may be used to demonstrate any postvoid residual, which may be quantitated and reported. In male patients, an attempt to measure the prostate gland may be made. Incidental gynecologic abnormalities in patients with female anatomy should be noted.
If there is concern for vesicoureteral reflux, particularly in children, contrast-enhanced voiding urosonography may be helpful [59,60].

10. Adrenal glands

When possible, long-axis and transverse images of the adrenal glands in the newborn or young infant may be obtained. Normal adrenal glands are less commonly seen by ultrasound in older children and adults [49]. Any incidental adrenal masses detected should be documented for further characterization.

11. 11. Aorta

Longitudinal grayscale imaging of the proximal, mid and distal segments of the abdominal aorta should be acquired. When evaluation of the aorta is specifically requested, see the ACR–AIUM–SRU Practice Parameter for the Performance of Diagnostic and Screening Ultrasound of the Abdominal Aorta in Adults [61,62].

12. Inferior vena cava

Representative images of the upper IVC may be obtained. When specific evaluation of the IVC is requested, patency and abnormalities may be evaluated with Doppler. Vena cava filters, interruption devices, and catheters may need to be localized with respect to the hepatic and/or renal veins [63].

VI. DOCUMENTATION

Reporting should be in accordance with the ACR Practice Parameter for Communication of Diagnostic Imaging Findings [64].

Adequate documentation is essential for high-quality patient care. There should be a permanent record of the ultrasound examination and its interpretation. Comparison with prior relevant imaging studies may prove helpful. Images of all appropriate areas, both normal and abnormal, should be recorded. Variations from normal size should generally be accompanied by measurements. The initials of the operator should be accessible on the images or electronically on PACS. Images should be labeled with the patient identification, facility identification, examination date, and image orientation. An official interpretation (final report) of the ultrasound examination should be included in the patient's medical record. Retention of the ultrasound examination images should be based on clinical need and relevant legal and local health care facility requirements.

VII. EQUIPMENT SPECIFICATIONS

Equipment performance monitoring should be in accordance with the ACR–AAPM Technical Standard for Diagnostic Medical Physics Performance Monitoring of Real Time Ultrasound Equipment [65].

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).

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 (https://www.acr.org/Clinical-Resources/Practice-Parameters-and-Technical-Standards) by the Committee on Practice Parameters – Ultrasound of the ACR Commission on Ultrasound and by the Committee on Practice Parameters – Pediatric Radiology of the Commission on Pediatric Radiology, in collaboration with the AIUM, the SPR, and the SRU.

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REFERENCES

1. Speets AA, Hoes AA, van der Graaf YY, et al. Upper abdominal ultrasound in general practice: indications, diagnostic yield and consequences for patient management. Fam Pract 23:507-11, .
2. American College of Radiology. ACR-AIUM-SPR-SRU Practice Parameter for the Performance of Contrast Enhanced Ultrasound. Available at https://gravitas.acr.org/PPTS/GetDocumentView?docId=25+&releaseId=2
3. American College of Radiology. ACR–SPR–SRU Practice Parameter for Performing and Interpreting Diagnostic Ultrasound Examinations. Available at: https://gravitas.acr.org/PPTS/GetDocumentView?docId=24+&releaseId=2
4. Benedetti NN, Desser TT, Jeffrey RR. Imaging of hepatic infections. Ultrasound Q 24:267-78, .
5. Desser TS, Sze DY, Jeffrey RB. Imaging and intervention in the hepatic veins. AJR Am J Roentgenol. 2003 Jun;180(6):1583-91.
6. Laing FC. Jaundice. In: Bluth EI, Benson CB, Ralls PW, Siegel MJ, ed. Ultrasound: A Practical Approach to Clinical Problems. 2nd ed. New York, NY: Thieme; 2008:17-35.
7. Muradali D, Chawla T. Organ transplantation. In: Rumack CM, Wilson SR, Charboneau JW, et al, ed. Diagnostic Ultrasound. 4th ed. Philadelphia, Pa: Elsevier Mosby; 2010:639-707.
8. Robbin ML, Abrams GA, Lockhart ME. Abnormal liver tests. In: Bluth EI, Benson CB, Ralls PW, Siegel MJ, ed. Ultrasound: A Practical Approach to Clinical Problems. 2nd ed. New York, NY: Thieme; 2008:36-52.
9. Siegel MJ. Liver. In: Siegel MJ, ed. Pediatric Sonography. 4th ed. Philadelphia, Pa: Lippincott, Williams & Wilkins; 2010.
10. American College of Radiology. ACR-AIUM-SPR-SRU Practice Parameter for the Performance of an Ultrasound Examination of Solid Organ Transplants. Available at https://gravitas.acr.org/PPTS/GetDocumentView?docId=55+&releaseId=2
11. Barr RR, Ferraioli GG, Palmeri MM, et al. Elastography Assessment of Liver Fibrosis: Society of Radiologists in Ultrasound Consensus Conference Statement. Radiology 276:845-61, .
12. Rodgers SK, Fetzer DT, Gabriel H, et al. Role of US LI-RADS in the LI-RADS Algorithm. [Review]. Radiographics. 39(3):690-708, 2019 May-Jun.
13. Lyshchik A, Kono Y, Dietrich CF, et al. Contrast-enhanced ultrasound of the liver: technical and lexicon recommendations from the ACR CEUS LI-RADS working group. Abdominal Radiology. 43(4):861-879, 2018 04.
14. Rafailidis VV, Fang CC, Yusuf GG, Huang DD, Sidhu PP. Contrast-enhanced ultrasound (CEUS) of the abdominal vasculature. Abdom Radiol (NY) 43:934-947, .
15. Ralls PW. Periampullary tumor: is it resectable? In: Bluth EI, Benson CB, Ralls PW, Siegel MJ, ed. Ultrasound: A Practical Approach to Clinical Problems. 2nd ed. New York, NY: Thieme; 2008:65-73.
16. Siegel MJ. Gallbladder and biliary tract. In: Siegel MJ, ed. Pediatric Sonography. 4th ed. Philadelphia, Pa: Lippincott, Williams & Wilkins; 2010.
17. Middleton WD. Right upper-quadrant pain. In: Bluth EI, Benson CB, Ralls PW, Siegel MJ, ed. Ultrasound: A Practical Approach to Clinical Problems. 2nd ed. New York, NY: Thieme; 2008:3-16.
18. Gandolfi L, Torresan F, Solmi L, Puccetti A. The role of ultrasound in biliary and pancreatic diseases. Eur J Ultrasound. 2003 Feb;16(3):141-59.
19. Hohl CC, Schmidt TT, Honnef DD, Günther RR, Haage PP. Ultrasonography of the pancreas. 2. Harmonic imaging. Abdom Imaging 32:150-60, .
20. Koito K, Namieno T, Nagakawa T, et al. Pancreas: imaging diagnosis with color/power Doppler ultrasonography, endoscopic ultrasonography, and intraductal ultrasonography. Eur J Radiol. 2001 May;38(2):94-104.
21. Ralls PW. Hyperamylasemia and acute pancreatitis. In: Bluth EI, Benson CB, Ralls PW, Siegel MJ, ed. Ultrasound: A Practical Approoach to Clinical Problems. 2nd ed. New York, NY: Thieme; 2008:74-83.
22. Chow KK, Luxembourg BB, Seifried EE, Bonig HH. Spleen Size Is Significantly Influenced by Body Height and Sex: Establishment of Normal Values for Spleen Size at US with a Cohort of 1200 Healthy Individuals. Radiology 279:306-13, .
23. Doria AA, Daneman AA, Moineddin RR, et al. High-frequency sonographic patterns of the spleen in children. Radiology 240:821-7, .
24. Sutherland TT, Temple FF, Hennessy OO, Lee WW. Abdomen's forgotten organ: Sonography and CT of focal splenic lesions. J Med Imaging Radiat Oncol 54:120-8, .
25. Hagen-Ansert SL. The spleen. In: Hagen-Ansert SL, ed. Textbook of Diagnostic Ultrasonography. 7th ed. Philadelphia, Pa: Elsevier-Mosby; 2011.
26. Siegel MJ. Spleen and peritoneal cavity. In: Siegel MJ, ed. Pediatric Sonography. 4th ed. Philadelphia, Pa: Lippincott, Williams & Wilkins; 2010.
27. Kuzmich SS, Howlett DD, Andi AA, Shah DD, Kuzmich TT. Transabdominal sonography in assessment of the bowel in adults. AJR Am J Roentgenol 192:197-212, .

28. Yabunaka K, Katsuda T, Sanada S, Fukutomi T. Sonographic appearance of the normal appendix in adults. J Ultrasound Med. 26(1):37-43; quiz 45-6, 2007 Jan.
29. Jeffrey RB. Right lower-quadrant pain: rule out appendicitis. In: Bluth EI, Benson CB, Ralls PW, Siegel MJ, ed. Ultrasound: A Practical Approach to Clinical Problems. 2nd ed. New York, NY: Thieme; 2008:134-44.
30. Siegel MJ. Gastrointestinal tract. In: Siegel MJ, ed. Pediatric Sonography. 4th ed. Philadelphia, Pa: Lippincott, Williams & Wilkins; 2010.
31. Wiersma F, Toorenvliet BR, Bloem JL, Allema JH, Holscher HC. US examination of the appendix in children with suspected appendicitis: the additional value of secondary signs. Eur Radiol. 19(2):455-61, 2009 Feb.
32. Epelman MM, Daneman AA, Navarro OO, et al. Necrotizing enterocolitis: review of state-of-the-art imaging findings with pathologic correlation. Radiographics 27:285-305, .
33. Migaleddu V, Scanu AM, Quaia E, et al. Contrast-enhanced ultrasonographic evaluation of inflammatory activity in Crohn's disease. Gastroenterology 2009; 137(1):43-52.
34. Strobel D, Goertz RS, Bernatik T. Diagnostics in inflammatory bowel disease: ultrasound. World J Gastroenterol. 2011;17(27):3192-3197.
35. Sasaki T, Kunisaki R, Kinoshita H, et al. Doppler ultrasound findings correlate with tissue vascularity and inflammation in surgical pathology specimens from patients with small intestinal Crohn's disease. BMC Res Notes. 7:363, 2014 Jun 14.
36. Medellin A, Merrill C, Wilson SR. Role of contrast-enhanced ultrasound in evaluation of the bowel. [Review]. Abdom Radiol. 43(4):918-933, 2018 04.
37. Ripolles T, Martinez MJ, Paredes JM, Blanc E, Flors L, Delgado F. Crohn disease: correlation of findings at contrast-enhanced US with severity at endoscopy. Radiology. 2009;253(1):241-248.
38. Serafin Z, Bialecki M, Bialecka A, Sconfienza LM, Klopocka M. Contrast-enhanced Ultrasound for Detection of Crohn's Disease Activity: Systematic Review and Meta-analysis. [Review]. J Crohns Colitis. 10(3):354-62, 2016 Mar.
39. Bryant RR, Friedman AA, Wright EE, et al. Gastrointestinal ultrasound in inflammatory bowel disease: an underused resource with potential paradigm-changing application. Gut 67:973-985, .
40. Cavalcoli FF, Zilli AA, Fraquelli MM, Conte DD, Massironi SS. Small Bowel Ultrasound beyond Inflammatory Bowel Disease: An Updated Review of the Recent Literature. Ultrasound Med Biol 43:1741-1752, .
41. Lu CC, Merrill CC, Medellin AA, Novak KK, Wilson SS. Bowel Ultrasound State of the Art: Grayscale and Doppler Ultrasound, Contrast Enhancement, and Elastography in Crohn Disease. J Ultrasound Med 38:271-288, .
42. Richards JR, McGahan JP. Focused Assessment with Sonography in Trauma (FAST) in 2017: What Radiologists Can Learn. [Review]. Radiology. 283(1):30-48, 2017 Apr.
43. Jamadar DD, Jacobson JJ, Morag YY, et al. Characteristic locations of inguinal region and anterior abdominal wall hernias: sonographic appearances and identification of clinical pitfalls. AJR Am J Roentgenol 188:1356-64, .
44. Beland MD, Walle NL, Machan JT, Cronan JJ. Renal cortical thickness measured at ultrasound: is it better than renal length as an indicator of renal function in chronic kidney disease? AJR. 2010; 195(2):W146-149.
45. Jimenez CC, Lopez MM, Gonzalez EE, Selgas RR. Ultrasonography in kidney transplantation: values and new developments. Transplant Rev (Orlando) 23:209-13, .
46. Park SS, Kim JJ, Cho KK. Complications of renal transplantation: ultrasonographic evaluation. J Ultrasound Med 26:615-33, .
47. Sutherland TT, Temple FF, Chang SS, Hennessy OO, Lee WW. Sonographic evaluation of renal transplant complications. J Med Imaging Radiat Oncol 54:211-8, .
48. Vester UU, Kranz BB, Hoyer PP. The diagnostic value of ultrasound in cystic kidney diseases. Pediatr Nephrol 25:231-40, .
49. Babcock DS, Patriquin HB. The pediatric kidney and adrenal glands. In: Rumack CM, Wilson SR, Charboneau JW, et al, ed. Diagnostic Ultrasound. 4th ed. Philadelphia, Pa: Elsevier Mosby; 2010:1845-90.
50. Middleton WD, Kurtz AB, Hertzberg BS. Kidney. Ultrasound: The Requisites. St. Louis, Mo: Mosby; 2004.
51. Siegel MJ. Urinary tract. In: Siegel MJ, ed. Pediatric Sonography. 4th ed. Philadelphia, Pa: Lippincott, Williams & Wilkins; 2010.
52. Tublin M, Thurston W, Wilson SR. The kidney and urinary tract. In: Rumack CM, Wilson SR, Charboneau JW, et al, ed. Diagnostic Ultrasound. 4th ed. Philadelphia, Pa: Elsevier Mosby; 2010.
53. Barr RG, Peterson C, Hindi A. Evaluation of indeterminate renal masses with contrast-enhanced US: a diagnostic performance study. Radiology. 271(1):133-42, 2014 Apr.
54. Bertolotto MM, Cicero CC, Perrone RR, Degrassi FF, Cacciato FF, Cova MM. Renal Masses With Equivocal Enhancement at CT: Characterization With Contrast-Enhanced Ultrasound. AJR Am J Roentgenol 204:W557-65, .
55. Kamaya A, Tuthill T, Rubin JM. Twinkling artifact on color Doppler sonography: dependence on machine parameters and underlying cause. AJR Am J Roentgenol. 2003 Jan;180(1):215-22.

56. Dillman JR, Kappil M, Weadock WJ, et al. Sonographic twinkling artifact for renal calculus detection: correlation with CT. Radiology. 2011; 259(3):911-916.
57. American College of Radiology. ACR-AIUM-SPR-SRU Practice Parameter for the Performance of Duplex Sonography of Native Renal Vessels. Available at https://gravitas.acr.org/PPTS/GetDocumentView?docId=26+&releaseId=2
58. Laing FF, Benson CC, DiSalvo DD, Brown DD, Frates MM, Loughlin KK. Distal ureteral calculi: detection with vaginal US. Radiology 192:545-8, .
59. Duran C, Beltran VP, Gonzalez A, Gomez C, Riego JD. Contrast-enhanced Voiding Urosonography for Vesicoureteral Reflux Diagnosis in Children. [Review]. Radiographics. 37(6):1854-1869, 2017 Oct.
60. Darge KK. Voiding urosonography with ultrasound contrast agents for the diagnosis of vesicoureteric reflux in children. I. Procedure. Pediatr Radiol 38:40-53, .
61. American College of Radiology. ACR-AIUM-SRU Practice Parameter for the Performance of Diagnostic and Screening Ultrasound of the Abdominal Aorta in Adults. Available at https://gravitas.acr.org/PPTS/GetDocumentView?docId=97+&releaseId=2
62. Sofka CM. Multicentre aneurysm screening study (MASS): cost-effectiveness analysis of screening for abdominal aortic aneurysms based on four-year results from randomized controlled trial. Ultrasound Quarterly 2003;19:106-07.
63. Wachsberg RR. Ultrasonography of the retrocrural region: normal and pathological findings. Ultrasound Q 22:281-90, .
64. American College of Radiology. ACR Practice Parameter for Communication of Diagnostic Imaging Findings. Available at https://gravitas.acr.org/PPTS/GetDocumentView?docId=74+&releaseId=2
65. American College of Radiology. ACR–AAPM Technical Standard for Diagnostic Medical Physics Performance Monitoring of Real Time Ultrasound Equipment. Available at https://gravitas.acr.org/PPTS/GetDocumentView?docId=118+&releaseId=2

*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.

Development Chronology for this Practice Parameter

1990 (Resolution 7)
Revised 1993 (Resolution 4)
Revised 2001 (Resolution 36)
Revised 2006 (Resolution 39, 35)
Revised 2007 (Resolution 24)
Revised 2012 (Resolution 29)
Amended 2014 (Resolution 39)
Revised 2017 (Resolution 27)
Revised 2021 (Resolution 32)
Amended 2023 (Resolution 2c)