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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.

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

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

The practice of medicine involves not only the science, but also the art of dealing with the prevention, diagnosis, alleviation, and treatment of disease. The variety and complexity of human conditions make it impossible to always reach the most appropriate diagnosis or to predict with certainty a particular response to treatment. Therefore, it should be recognized that adherence to these practice parameters will not assure an accurate diagnosis or a successful outcome. All that should be expected is that the practitioner will follow a reasonable course of action based on current knowledge, available resources, and the needs of the patient to deliver effective

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.

and safe medical care. The sole purpose of these practice parameters is to assist practitioners in achieving this objective.

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). 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.

II. INDICATIONS/CONTRAINDICATIONS

A. 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 or abnormal findings on other imaging examinations suggestive of abdominal and/or retroperitoneal pathology
5. Follow-up of known or suspected abnormalities in the abdomen and/or retroperitoneum
6. Search for metastatic disease or occult primary neoplasm
7. Evaluation of cirrhosis, portal hypertension, and transjugular intrahepatic portosystemic shunt (TIPS) stents; screening for hepatoma; evaluation of the liver in conjunction with liver elastography
8. Abdominal trauma
9. Evaluation of urinary tract infection and hydronephrosis
10. Evaluation of uncontrolled hypertension and suspected renal artery stenosis
11. Search for the presence of free or loculated peritoneal and/or retroperitoneal fluid
12. Evaluation of suspected congenital abnormalities
13. Evaluation of suspected hypertrophic pyloric stenosis, intussusception, necrotizing enterocolitis, or any other bowel abnormalities
14. Pretransplantation and post-transplantation evaluation
15. Planning for and guiding an invasive procedure

B. 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 THE PHYSICIAN

Each organization will address this section in its document. ACR language is as follows:

See the [ACR–SPR–SRU Practice Parameter for Performing and Interpreting Diagnostic Ultrasound Examinations](#) [2].

IV. WRITTEN REQUEST FOR THE EXAMINATION

Each organization will address this section in its document. ACR language is as follows:

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)

V. SPECIFICATIONS FOR INDIVIDUAL EXAMINATIONS

Spectral, color, and power Doppler may be useful to differentiate vascular from nonvascular structures in any location. Measurements should be considered for any abnormal area [3]. Additionally, cine clips may be a helpful tool in any of these examinations, particularly when screening for malignancy. Ultrasound contrast may have applications in abdominal and retroperitoneal ultrasound.

1. Liver

The examination of the liver should include long axis and transverse views. Liver measurement may be performed on longitudinal images. 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, the main portal vein, and, if possible, the right and left branches of 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 possible surface nodularity in patients at risk for cirrhosis.
- d. For vascular examinations, 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 transjugular intrahepatic portosystemic shunt (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].

In addition, in patients predisposed to or suspected of having hepatic fibrosis, hepatic elastography may be performed [11].

2. Gallbladder and biliary tract

Routine gallbladder examination should be conducted on an adequately distended gallbladder whenever possible. In most cases, fasting 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. Measurements may aid in determining gallbladder wall thickening. If the patient presents with pain, tenderness to transducer compression over the gallbladder should be assessed.

The intrahepatic 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 bile duct in the porta hepatis should be measured and documented. When visualized, the distal common bile duct in the pancreatic head should be evaluated [12-15].

3. Pancreas

Whenever possible, all portions of the pancreas—head, uncinate process, body, and tail—should be identified. Orally administered water or contrast agent and changes in patient positioning such as upright or decubitus positions may afford better visualization of the pancreas. The following should be assessed in the examination of the pancreas [15-18]:

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

4. Spleen

Representative views of the spleen in long-axis and transverse planes should be obtained. Splenic length measurement may be helpful in assessing enlargement. Echogenicity of the left kidney should be compared to splenic echogenicity when possible. An attempt should be made to demonstrate the left hemidiaphragm and the adjacent pleural space [3,19-21].

5. Bowel

When there is concern for bowel pathology, the bowel may be evaluated for wall thickening, dilatation, muscular hypertrophy, masses, vascularity, and other abnormalities. Sonography of the pylorus and surrounding structures may be indicated in the evaluation of the vomiting infant. Graded compression sonography aids in the visualization of the appendix and other bowel loops. Measurements may aid in determining bowel wall thickening, and color or power Doppler may be helpful in assessing hypervascularity [22-30].

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 for an examination otherwise focused on the abdomen.

In the setting of trauma, particularly blunt trauma, the examination known as focused abdominal sonographic examination for trauma (FAST) assessment (or focused assessment with sonography for trauma) may be performed to evaluate the peritoneal spaces for bleeding [31]. 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, with attention to fluid collections peripheral to the liver and in the subhepatic space. Longitudinal and transverse plane images should be obtained in the left upper quadrant through the area of the spleen, with attention to fluid collections peripheral to the spleen. Longitudinal and transverse images should be obtained at the periphery of the left and right abdomen in the areas of the left and right paracolic gutters for evidence of free fluid. Longitudinal and transverse midline images of the pelvis are obtained to evaluate for free pelvic fluid. Analysis through a fluid-filled bladder (which may be filled through a catheter, when necessary) may help in the evaluation of the pelvis.

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, or other abnormalities. The examination should include images of the abdominal wall in the location of symptoms or signs. 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, or other tissue contained within any abdominal wall defect should be noted. For detection of hernias, Valsalva maneuvers and upright positioning may be helpful. Doppler examination may be useful to define the relationship of blood vessels to a detected mass.

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 native 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 native kidneys. When possible, renal echogenicity should be compared to the adjacent liver or spleen. Renal cortical thickness should be assessed [32]. 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 [7,33-40]. Color Doppler imaging may be helpful in detecting calculi via the twinkling artifact [41,42].

For vascular examination of the native kidneys, Doppler may be used:

- a. To assess renal arterial and venous patency
- b. To evaluate suspected renal artery stenosis. For this application, angle-adjusted measurements of the peak systolic velocity should be made proximally, centrally, and distally in the extrarenal portion of the main renal arteries when possible. Peak systolic velocity of the adjacent aorta should also be documented for calculating the ratio of renal to aortic peak systolic velocity. Spectral Doppler evaluation of the intrarenal arteries may be of value as indirect evidence of proximal stenosis in the main renal artery.
- c. 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 hydronephrosis to evaluate for the presence of obstruction. Transvaginal ultrasound may also be a helpful tool in evaluating distal ureteral calculi in women [43]. 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 a female patient should be noted.

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 [37]. Any masses detected should be documented.

11. Aorta

Representative images of the aorta may be obtained. 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](#) [44,45].

12. Inferior vena cava

Representative images of the 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 [46].

VI. DOCUMENTATION

Each organization will address this section in its document. ACR language is as follows:

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.

Reporting should be in accordance with the [ACR Practice Parameter for Communication of Diagnostic Imaging Findings](#) [47].

VII. EQUIPMENT SPECIFICATIONS

Abdomen and/or retroperitoneum sonographic studies should be conducted with real-time scanners, preferably using curved sector or linear transducers. The equipment should be adjusted to operate at the highest clinically appropriate frequency, realizing that there is a trade-off between resolution and beam penetration. For most preadolescent pediatric patients, mean frequencies of 5 MHz or greater are preferred, and in newborns and small infants a higher frequency transducer is often necessary. For adults, mean frequencies between 4 and 6 MHz are most commonly used. Higher frequencies are often used and needed when evaluating the abdominal wall, liver surface, and bowel. Color and power Doppler should be used to characterize vascular structures and masses.

When Doppler studies are performed, the Doppler frequency may differ from the imaging frequency. Image quality should be optimized while keeping total ultrasound exposure as low as reasonably achievable.

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

Each organization will address this section in its document. ACR language is as follows:

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>).

Equipment performance monitoring should be in accordance with the [ACR–AAPM Technical Standard for Diagnostic Medical Physics Performance Monitoring of Real Time Ultrasound Equipment](#) [48].

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REFERENCES

1. Speets AM, Hoes AW, van der Graaf Y, et al. Upper abdominal ultrasound in general practice: indications, diagnostic yield and consequences for patient management. *Fam Pract.* 2006;23(5):507-511.
2. American College of Radiology. ACR-SPR-SRU practice parameter for performing and interpreting diagnostic ultrasound examinations. 2014; Available at: <http://www.acr.org/~media/13B896B9F4844E3082E7D7ED66AFC148.pdf>. Accessed November 5, 2015.
3. Hagen-Ansert SL. The spleen. In: Hagen-Ansert SL, ed. *Textbook of Diagnostic Ultrasonography*. 7th ed. Philadelphia, Pa: Elsevier-Mosby; 2011.
4. Benedetti NJ, Desser TS, Jeffrey RB. Imaging of hepatic infections. *Ultrasound Q.* 2008;24(4):267-278.
5. Desser TS, Sze DY, Jeffrey RB. Imaging and intervention in the hepatic veins. *AJR Am J Roentgenol.* 2003;180(6):1583-1591.
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 Solid Organ Transplants. 2014; Available at: <http://www.acr.org/~media/89C78E344D454E98AF39187781FD864B.pdf>. Accessed February 25, 2016.
11. Barr RG, Ferraioli G, Palmeri ML, et al. Elastography Assessment of Liver Fibrosis: Society of Radiologists in Ultrasound Consensus Conference Statement. *Radiology*. 2015;276(3):845-861.
12. 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.
13. Siegel MJ. Gallbladder and biliary tract. In: Siegel MJ, ed. *Pediatric Sonography*. 4th ed. Philadelphia, Pa: Lippincott, Williams & Wilkins; 2010.
14. 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.
15. Gandolfi L, Torresan F, Solmi L, Puccetti A. The role of ultrasound in biliary and pancreatic diseases. *Eur J Ultrasound*. 2003;16(3):141-159.
16. Hohl C, Schmidt T, Honnef D, Gunther RW, Haage P. Ultrasonography of the pancreas. 2. Harmonic imaging. *Abdom Imaging*. 2007;32(2):150-160.
17. 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;38(2):94-104.
18. Ralls PW. Hyperamylasemia and acute pancreatitis. In: Bluth EI, Benson CB, Ralls PW, Siegel MJ, ed. *Ultrasound: A Practical Approach to Clinical Problems*. 2nd ed. New York, NY: Thieme; 2008:74-83.
19. Doria AS, Daneman A, Moineddin R, et al. High-frequency sonographic patterns of the spleen in children. *Radiology*. 2006;240(3):821-827.
20. Sutherland T, Temple F, Hennessy O, Lee WK. Abdomen's forgotten organ: Sonography and CT of focal splenic lesions. *J Med Imaging Radiat Oncol*. 2010;54(2):120-128.
21. Siegel MJ. Spleen and peritoneal cavity. In: Siegel MJ, ed. *Pediatric Sonography*. 4th ed. Philadelphia, Pa: Lippincott, Williams & Wilkins; 2010.
22. Kuzmich S, Howlett DC, Andi A, Shah D, Kuzmich T. Transabdominal sonography in assessment of the bowel in adults. *AJR Am J Roentgenol*. 2009;192(1):197-212.
23. Yabunaka K, Katsuda T, Sanada S, Fukutomi T. Sonographic appearance of the normal appendix in adults. *J Ultrasound Med*. 2007;26(1):37-43; quiz 45-36.
24. 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; 2008:134-144.
25. Siegel MJ. Gastrointestinal tract. In: Siegel MJ, ed. *Pediatric Sonography*. 4th ed. Philadelphia, Pa: Lippincott, Williams & Wilkins; 2010.
26. 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*. 2009;19(2):455-461.
27. Epelman M, Daneman A, Navarro OM, et al. Necrotizing enterocolitis: review of state-of-the-art imaging findings with pathologic correlation. *Radiographics*. 2007;27(2):285-305.
28. 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.
29. Strobel D, Goertz RS, Bernatik T. Diagnostics in inflammatory bowel disease: ultrasound. *World journal of gastroenterology*. 2011;17(27):3192-3197.
30. 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 research notes*. 2014;7:363.
31. Patel NY, Riherd JM. Focused assessment with sonography for trauma: methods, accuracy, and indications. *Surg Clin North Am*. 2011;91(1):195-207.
32. 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 Am J Roentgenol*. 2010;195(2):W146-149.
33. Jimenez C, Lopez MO, Gonzalez E, Selgas R. Ultrasonography in kidney transplantation: values and new developments. *Transplant Rev (Orlando)*. 2009;23(4):209-213.

34. Park SB, Kim JK, Cho KS. Complications of renal transplantation: ultrasonographic evaluation. *J Ultrasound Med.* 2007;26(5):615-633.
35. Sutherland T, Temple F, Chang S, Hennessy O, Lee WK. Sonographic evaluation of renal transplant complications. *J Med Imaging Radiat Oncol.* 2010;54(3):211-218.
36. Vester U, Kranz B, Hoyer PF. The diagnostic value of ultrasound in cystic kidney diseases. *Pediatr Nephrol.* 2010;25(2):231-240.
37. 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; 2010:1845-1890.
38. Middleton WD, Kurtz AB, Hertzberg BS. Kidney. *Ultrasound: The Requisites.* St. Louis, Mo: Mosby; 2004.
39. Siegel MJ. Urinary tract. In: Siegel MJ, ed. *Pediatric Sonography.* 4th ed. Philadelphia, Pa: Lippincott, Williams & Wilkins; 2010.
40. 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.
41. Kamaya A, Tuthill T, Rubin JM. Twinkling artifact on color Doppler sonography: dependence on machine parameters and underlying cause. *AJR Am J Roentgenol.* 2003;180(1):215-222.
42. Dillman JR, Kappil M, Weadock WJ, et al. Sonographic twinkling artifact for renal calculus detection: correlation with CT. *Radiology.* 2011;259(3):911-916.
43. Laing FC, Benson CB, DiSalvo DN, Brown DL, Frates MC, Loughlin KR. Distal ureteral calculi: detection with vaginal US. *Radiology.* 1994;192(2):545-548.
44. American College of Radiology. ACR–AIUM–SRU practice parameter for the performance of diagnostic and screening ultrasound of the abdominal aorta in adults. 2015; Available at: <http://www.acr.org/~media/102C4741C2A44691939F0EE3258E0BD2.pdf>. Accessed November 5, 2015.
45. 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(2):106-107.
46. Wachsberg RH. Ultrasonography of the retrocrural region: normal and pathological findings. *Ultrasound Q.* 2006;22(4):281-290.
47. American College of Radiology. ACR practice parameter for communication of diagnostic imaging findings. 2015; Available at: <http://www.acr.org/~media/C5D1443C9EA4424AA12477D1AD1D927D.pdf>. Accessed November 5, 2015.
48. American College of Radiology. ACR–AAPM technical standard for diagnostic medical physics performance monitoring of real time ultrasound equipment. 2016; Available at: <http://www.acr.org/~media/152588501B3648BA803B38C8172936F9.pdf>. Accessed July 7, 2016.

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Development Chronology for this Practice Parameter

- Adopted 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)