

ACR–AIUM–SRU PRACTICE PARAMETER FOR THE PERFORMANCE OF ULTRASOUND VESSEL MAPPING PRIOR TO DIALYSIS ACCESS CREATION

Revised 2021 (Resolution 35)

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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 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 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.

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), and the Society of Radiologists in Ultrasound (SRU). Recommendations for physician requirements, written request for the examination, procedure documentation, and quality control vary between the 3 organizations and are addressed by each separately.

Single-center studies have shown that preprocedural mapping of arm vessels prior to creation of hemodialysis access maximizes arteriovenous fistula (AVF) creation rate and increases the use of AVF in the hemodialysis population. Two randomized control trials and an observational trial assessing the utility of preoperative ultrasound versus thorough clinical evaluation have not shown a clear benefit [1-9]. Although it may not be necessary in patients whose physical examination is favorable for AVF, it is likely of benefit in patients at high risk for AVF failure, those with prior central venous catheters, and/or those with inadequate physical examination.

This practice parameter is intended to help physicians and sonographers facilitate the performance of preprocedural mapping, guarantee a high-quality examination, and assist in successful creation of the optimal hemodialysis access. Kidney Disease Outcomes Quality Initiative (K/DOQI) guidelines [8] define an order of preference for placement of vascular access in patients with kidney failure who will become hemodialysis dependent:

1. The nondominant arm is the preferred site for dialysis access placement and is usually evaluated first. The general consensus among physicians is that new hemodialysis access, if possible, should be placed in the upper extremity utilizing the most distal adequate veins available to preserve more central veins in the case of fistula failure and a need for subsequent arteriovenous (AV) access creation. Therefore, a forearm AVF is preferred over an upper arm AVF. A forearm AVF in the dominant arm may be preferred over an upper arm AVF in the nondominant arm, depending on procedural preference.
2. The cephalic vein is the superficial upper-extremity vein that is most commonly utilized for AVF creation. The radiocephalic AVF (radial artery-cephalic vein) at the wrist is the first choice for hemodialysis access. If not available, the next most preferred fistula is created between the brachial artery and the cephalic vein in the antecubital fossa or the proximal radial artery and the cephalic vein in the proximal forearm.
3. If the cephalic vein is deemed inadequate for access creation, access may be established using a basilic vein transposition AVF (brachial artery–basilic vein) or other AVF configuration such as a brachial vein transposition AVF (brachial artery–brachial vein). A brachial-basilic transposition fistula is created at a deeper depth based upon the native position of the vessels and often requires a second superficialization procedure to bring the AVF draining vein closer to the skin surface for easier hemodialysis needle insertion.
4. When the vessel anatomy is not suitable for AVF creation, a synthetic arteriovenous graft (AVG) (eg, polytetrafluoroethylene, abbreviated PTFE) may be used. A forearm loop graft (brachial artery to antecubital vein) is preferred over an upper arm straight graft (brachial artery to basilic vein), as more proximal vessels are preserved for future access placement. If no other upper-extremity access is possible, an upper arm loop graft (axillary artery to axillary vein) may be placed if the anatomy is suitable.
5. Thigh autogenous or synthetic grafts (superficial femoral artery to great saphenous vein or common femoral vein) are the next usual site for access creation [10,11].
6. Creation of AVF or AVG is preferred to catheter-based hemodialysis because of increased catheter infection rates and often lower catheter flow rates as compared with a graft or fistula [12].

II. INDICATIONS/CONTRAINDICATIONS

Indications for preprocedural vessel mapping include assessment of arterial and venous systems prior to procedural planning of hemodialysis access creation. There are no absolute contraindications for this examination.

III. QUALIFICATIONS AND RESPONSIBILITIES OF PERSONNEL

See the [ACR–SPR–SRU Practice Parameter for the Performance and Interpretation of Diagnostic Ultrasound Examinations](#) [13].

IV. Written Request for the Examination

The written or electronic request for an ultrasound preprocedural vessel mapping 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 OF THE EXAMINATION

The ultrasound examination for vessel mapping is designed to gather anatomic and hemodynamic information about both the arterial and venous system. It is important to understand the procedure and procedural options available to the access surgeon(s) in order to obtain the required information. Both arms can be mapped in their entirety, or a more focused preprocedural mapping can be performed that concludes when vessels adequate for AVF formation are found, based on local preference. Of note, all artery and vein inner lumen measurements are performed in the anteroposterior (AP) dimension in the transverse plane, taking care to not compress the vessel from its normal round shape by transducer pressure.

A. Arterial Examination

The arm examination can be bilateral or unilateral, depending on laboratory and surgeon preference. If a unilateral examination is performed, the nondominant arm is examined first unless there is a contraindication to the use of that arm. The artery used must be of sufficient size to construct the fistula and to provide enough flow for maturation and adequate hemodialysis treatment. This size may vary according to procedural preference. Generally accepted minimum vessel size criteria is inner diameter of ≥ 0.20 cm, but this may vary with a trend toward increasing unassisted AVF maturation with increasing artery size [6,8,14-19]. The artery is evaluated with grayscale and spectral Doppler imaging. Grayscale ultrasound is useful for evaluation of calcifications and plaque formation. Color and spectral Doppler waveform analysis can aid in detection of inflow and outflow disease. The internal luminal diameter of the artery is measured at the level of expected fistula creation with the measurements obtained in short axis of a vessel in transverse and anterior-posterior dimensions. The presence of calcification at this site is also recorded and reported because the procedural anastomosis can be difficult if significant concentric calcification is present.

For a forearm AVF, diameter, presence of calcification, and peak systolic/end diastolic velocities of the radial artery are assessed at the wrist. Ulnar arteries may be similarly assessed. For either AVF or AVG surgery, the brachial artery is assessed at the antecubital fossa for diameter, presence of calcification, and peak systolic/end diastolic velocities. An artery in the antecubital fossa that is smaller than expected or the presence of 2 arteries at this site is a clue that there is a high brachial artery bifurcation, a normal anatomic variant that occurs in approximately 10% of patients [20]. This anatomic variant should be confirmed by imaging the radial and ulnar arteries to determine at what level they arise from the brachial artery. If noted, it should be reported, as some physicians will place an AVF, but not a graft, distal to a high brachial artery bifurcation. A modified duplex Allen test may be performed to evaluate flow to the hand (patency of the deep palmar arch). This is done by identifying the radial artery at the wrist and/or at the dorsum of the hand (posteriorly between the bases of the first and second metacarpals). The radial artery is compressed proximal to this site to occlude flow during insonation with spectral and color Doppler. Reversal of blood flow distal to the proximal occlusion confirms patency of the palmar arch [21].

B. Venous Examination

The nondominant arm is examined first unless there is a known contraindication to the use of that arm. The

vein that is planned to receive the arterial anastomosis should be measured after it is dilated. Measurement of the vein after application of a tourniquet will more closely approximate the size of the arterialized vein following fistula formation. The vein is generally dilated by use of sequential tourniquet placement or an inflated blood pressure cuff on the arm [22,23]. Percussion in the region of the wrist after tourniquet placement for 2 to 3 minutes can increase the size of the veins, similar to starting an intravenous (IV) line. Other suitable dorsal or volar caudal forearm veins may be identified with this technique. If no suitable vein is found, veins suitable for graft creation are sought.

The forearm vein most commonly used for AVF creation is the cephalic vein. The anastomosis is usually created at the wrist or in the lower one-third of the forearm. The cephalic vein is assessed throughout its course from the level of the wrist (a site of potential anastomosis) to the level of the confluence with either the subclavian or axillary vein for patency, compressibility, presence of thrombus, depth from the skin, and size. Size measurements are obtained for all veins. Generally, a minimal diameter of 0.25 cm is acceptable, although there may be variations based on clinical factors or procedural preference [6,8,14-18]. Vein diameter is measured at the proximal, mid, and distal forearm; at the antecubital fossa; and at the proximal, mid, and distal upper arm, as applicable. If venous stenosis is detected, the location, diameter, and length of the stenotic segment are reported. Veins that are borderline in size (within 0.05 cm of the desired size) are remeasured after dilatation in response to manual focused percussion or after temporary application of a warm compress. If a sclerotic or thick-walled vein is seen, its inner luminal diameter is measured and documented.

Focal narrowing of the vein at any level may preclude maturation of an AVF. Note that in case of more central cephalic vein thrombosis or hypoplasia, the forearm portion of the cephalic vein may drain preferentially via a large antecubital vein into the basilic or brachial veins. Creation of a forearm fistula is still possible as long as diameter thresholds are maintained. Successful AVF maturation is best achieved with a vein diameter of 0.25 cm or greater, although there may be variations based on clinical factors or procedural preference [6,8,14-18].

Veins must be relatively superficial to be easily accessed after creation of a fistula. The distance from the skin surface to the cephalic vein may be measured to assess the need for a subsequent superficialization procedure [23,24].

If the cephalic vein in the forearm is found to be inadequate for fistula creation, other veins in the forearm may be examined in similar fashion to determine whether they are adequate. Transposition to a more superficial location may be required in order to improve accessibility of the vein during dialysis. If no suitable vein is found in the forearm, the veins in the upper arm are evaluated.

If the cephalic vein is too small, thick-walled, or contains thrombus, the basilic vein is evaluated. The basilic vein needs to be of adequate diameter and at least 4 cm in length caudal to the antecubital fossa in the proximal forearm or there must be an adequate median cubital vein draining into the basilic vein so there is enough vein length to create a basilic vein transposition AVF in the upper arm. If no suitable upper arm vein for AVF creation is found, the largest brachial vein and the axillary vein should be measured for potential graft placement as previously described. A vein with a diameter of at least 0.4 cm has been suggested for grafts [6,11].

Similar assessment techniques should be applied for all veins evaluated (ie, vein inner lumen measurement after dilatation, demonstration of patency, compressibility, and determination of adequate venous drainage).

A comment should be made about the presence of large associated vein accessory branches as they may result in fistula nonmaturation [25,26]. The sites and sizes of accessory vein branches within the first 10 to 15 cm of the expected AVF draining vein may be documented.

The internal jugular and subclavian veins should be examined bilaterally to document symmetric respiratory phasicity and transmitted cardiac pulsatility, as well as to exclude outflow stenosis. These veins should be evaluated with compression if possible, with grayscale, spectral, and color Doppler. Unilateral or bilateral monophasic waveforms or low-velocity venous waveforms are abnormal [27,28]. Abnormal waveforms in the jugular or subclavian veins should prompt further evaluation of the brachiocephalic veins and/or superior vena cava (SVC) by magnetic resonance imaging (MRI), computed tomography (CT), or conventional venography if hemodialysis access creation on that side is desired [29].

VI. DOCUMENTATION

Reporting should be in accordance with the [ACR Practice Parameter for Communication of Diagnostic Imaging Findings](#) [30].

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](#) [31].

Real-time imaging should be conducted at the highest clinically appropriate frequency, realizing that there is a trade-off between resolution and beam penetration. This should usually be at a frequency of 12 to 18 MHz, with the occasional need for a lower-frequency transducer. A linear transducer should be used. Flow analyses are performed with duplex sonography using pulsed Doppler. Evaluation of the flow signals originating from within the lumen of the vessels should be conducted with a carrier frequency of 2.5 MHz or above. A lower-frequency sector transducer placed in the sternal notch may be useful to look for venous stenosis in the brachiocephalic veins or SVC if a central stenosis is suspected from abnormal subclavian and internal jugular vein waveforms. Images of the relevant grayscale, color, and spectral Doppler waveforms should be recorded and archived. Color Doppler should be used for relevant portions of the procedure.

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

Policies and procedures related to quality, patient education, infection control, and safety should be developed and implemented in accordance with the ACR Policy on Quality Control and Improvement, Safety, Infection Control, and Patient Education appearing under the heading *ACR Position Statement on Quality Control & Improvement, Safety, Infection Control, and Patient Education* on the ACR website (<https://www.acr.org/Advocacy-and-Economics/ACR-Position-Statements/Quality-Control-and-Improvement>).

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

ACR

Michelle L. Robbin, MD, MS, FACR, FAIUM, FSRU, Chair

Christopher Fung, MD

AIUM

George Berdejo, BA, RVT, FSVU

Margarita V. Revzin, MD, MS, FSRU, FAIUM

Sheila Sheth, MD, FACR

SRU

Wui Kheong Chong, MD

Committee on Practice Parameters – Ultrasound

(ACR Committee responsible for sponsoring the draft through the process)

Sheila Sheth, MD, FACR, Chair

Stephen I. Johnson, MD

Nirvikar Dahiya, MD, FAIUM, FSRU, Vice Chair

Michelle L Melany, MD, FACR

Osama Ali, MD

Harriet J. Paltiel, MD

Marcela Böhm-Velez, MD, FACR

Rupinder Penna, MD

Baljot S. Chahal, MD, MBA, BSc

Kristin L. Rebik, DO

Christopher Fung, MD

Henrietta K. Rosenberg, MD, FACR

Helena Gabriel, MD

Judy H. Squires, MD

Jamie Hui, MD

Joel P. Thompson, MD

Lauren P. Golding, MD, Chair, Commission on Ultrasound

David B. Larson, MD, MBA, Chair, Commission on Quality and Safety

Mary S. Newell, MD, FACR, Chair, Committee on Practice Parameters and Technical Standards

Comment Reconciliation Committee

Elizabeth Ann Ignacio, MD, Chair

Amy Kotsenas, MD, FACR

Eve Clark, MD, Co-Chair

David B. Larson, MD, MBA

Susan J. Back, MD

Paul A. Larson, MD, FACR

Comment Reconciliation Committee

Richard A. Barth, MD, FACR

Terry L. Levin, MD, FACR

George Berdejo, BA, RVT, FSVU

Mary S. Newell, MD, FACR

Wui Kheong Chong, MD

Margarita V. Revzin, MD, MS, FSRU, FAIUM

Richard Duszak Jr., MD, FACR

Michelle L. Robbin, MD, MS, FACR, FAIUM, FSRU

Christopher Fung, MD

Sheila Sheth, MD, FACR

Lauren P. Golding, MD

REFERENCES

1. Nursal TZ, Oguzkurt L, Tercan F, et al. Is routine preoperative ultrasonographic mapping for arteriovenous fistula creation necessary in patients with favorable physical examination findings? Results of a randomized controlled trial. *World J Surg* 2006;30:1100-7.
2. Yaghoubian A, Lewis RJ, de Virgilio C. Can the National Kidney Foundation Guidelines for First-Time Arteriovenous Fistula Creation Be Met in Underserved End-Stage Renal Disease Patients? *Annals of Vascular Surgery* 2008;22:5-10.
3. Allon M, Lockhart ME, Lilly RZ, et al. Effect of preoperative sonographic mapping on vascular access outcomes in hemodialysis patients. *Kidney Int* 2001;60:2013-20.
4. Allon M, Robbin ML. Increasing arteriovenous fistulas in hemodialysis patients: problems and solutions. *Kidney Int* 2002;62:1109-24.
5. Robbin ML, Gallichio MH, Deierhoi MH, Young CJ, Weber TM, Allon M. US vascular mapping before hemodialysis access placement. *Radiology* 2000;217:83-8.
6. Silva MB, Jr., Hobson RW, 2nd, Pappas PJ, et al. A strategy for increasing use of autogenous hemodialysis access procedures: impact of preoperative noninvasive evaluation. *J Vasc Surg* 1998;27:302-7; discussion 07-8.
7. Ferring M, Claridge M, Smith SA, Wilmint T. Routine preoperative vascular ultrasound improves patency and use of arteriovenous fistulas for hemodialysis: a randomized trial. *Clinical journal of the American Society of Nephrology : CJASN* 2010;5:2236-44.
8. Lok CE, Huber TS, Lee T, et al. KDOQI Clinical Practice Guideline for Vascular Access: 2019 Update. *American Journal of Kidney Diseases* 2020;75:S1-S164.
9. Wong CS, McNicholas N, Healy D, et al. A systematic review of preoperative duplex ultrasonography and arteriovenous fistula formation. *J Vasc Surg* 2013;57:1129-33.
10. Khadra MH, Dwyer AJ, Thompson JF. Advantages of polytetrafluoroethylene arteriovenous loops in the thigh for hemodialysis access. *Am J Surg* 1997;173:280-3.
11. Little MD, Allon M, McNamara MM, et al. Risk Evaluation of Immediate Surgical Failure During Thigh Hemodialysis Graft Placement by Sonographic Screening. *J Ultrasound Med* 2015;34:1613-9.
12. Lee T, Barker J, Allon M. Tunneled catheters in hemodialysis patients: reasons and subsequent outcomes. *Am J Kidney Dis* 2005;46:501-8.
13. American College of Radiology. ACR–SPR–SRU Practice Parameter for the Performance and Interpretation of Diagnostic Ultrasound Examinations. Available at: <https://www.acr.org/-/media/ACR/Files/Practice-Parameters/US-Perf-Interpret.pdf>. Accessed January 15, 2020.
14. Malovrh M. Native arteriovenous fistula: preoperative evaluation. *Am J Kidney Dis* 2002;39:1218-25.

15. Zhang F, Li Y, Wang T, et al. Influence of cephalic vein dilation on arteriovenous fistula maturation in patients with small cephalic veins. *Medicine (Baltimore)* 2020;99:e18576.
16. Waheed A, Masengu A, Skala T, Li G, Jastrzebski J, Zalunardo N. A prospective cohort study of predictors of upper extremity arteriovenous fistula maturation. *J Vasc Access* 2020;1129729820907471.
17. Misskey J, Hamidzadeh R, Faulds J, Chen J, Gagnon J, Hsiang Y. Influence of artery and vein diameters on autogenous arteriovenous access patency. *Journal of Vascular Surgery* 2020;71:158-72.e1.
18. Sidawy AN, Spergel LM, Besarab A, et al. The Society for Vascular Surgery: clinical practice guidelines for the surgical placement and maintenance of arteriovenous hemodialysis access. *J Vasc Surg* 2008;48:2S-25S.
19. Farrington CA, Robbin ML, Lee T, Barker-Finkel J, Allon M. Early Predictors of Arteriovenous Fistula Maturation: A Novel Perspective on an Enduring Problem. *J Am Soc Nephrol* 2020;31:1617-27.
20. Kian K, Shapiro JA, Salman L, et al. High brachial artery bifurcation: clinical considerations and practical implications for an arteriovenous access. *Seminars in dialysis* 2012;25:244-7.
21. Zimmerman P, Chin E, Laifer-Narin S, Ragavendra N, Grant EG. Radial artery mapping for coronary artery bypass graft placement. *Radiology* 2001;220:299-302.
22. Lockhart ME, Robbin ML, Fineberg NS, Wells CG, Allon M. Cephalic vein measurement before forearm fistula creation: does use of a tourniquet to meet the venous diameter threshold increase the number of usable fistulas? *J Ultrasound Med* 2006;25:1541-5.
23. Pietryga JA, Little MD, Robbin ML. Sonography of Arteriovenous Fistulas and Grafts. *Seminars in dialysis* 2017;30:309-18.
24. Robbin ML, Chamberlain NE, Lockhart ME, et al. Hemodialysis arteriovenous fistula maturity: US evaluation. *Radiology* 2002;225:59-64.
25. Beathard GA, Arnold P, Jackson J, Litchfield T. Aggressive treatment of early fistula failure. *Kidney Int* 2003;64:1487-94.
26. Singh P, Robbin ML, Lockhart ME, Allon M. Clinically immature arteriovenous hemodialysis fistulas: effect of US on salvage. *Radiology* 2008;246:299-305.
27. Chin EE, Zimmerman PT, Grant EG. Sonographic evaluation of upper extremity deep venous thrombosis. *J Ultrasound Med* 2005;24:829-38; quiz 39-40.
28. Patel MC, Berman LH, Moss HA, McPherson SJ. Subclavian and internal jugular veins at Doppler US: abnormal cardiac pulsatility and respiratory phasicity as a predictor of complete central occlusion. *Radiology* 1999;211:579-83.
29. Tedla FM, Clerger G, Distant D, Salifu M. Prevalence of Central Vein Stenosis in Patients Referred for Vein Mapping. *Clinical journal of the American Society of Nephrology : CJASN* 2018;13:1063-68.
30. American College of Radiology. ACR practice parameter for communication of diagnostic imaging findings. Available at: <https://www.acr.org/-/media/ACR/Files/Practice-Parameters/CommunicationDiag.pdf>. Accessed January 15, 2020.
31. American College of Radiology. ACR-AAPM technical standard for diagnostic medical physics performance monitoring of real time ultrasound equipment. Available at: <https://www.acr.org/-/media/ACR/Files/Practice-Parameters/US-Equip.pdf>. Accessed January 15, 2020.

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