The American College of Radiology, with more than 30,000 members, is the principal organization of radiologists, radiation oncologists, and clinical medical physicists in the United States. The College is a nonprofit professional society whose primary purposes are to advance the science of radiology, improve radiologic services to the patient, study the socioeconomic aspects of the practice of radiology, and encourage continuing education for radiologists, radiation oncologists, medical physicists, and persons practicing in allied professional fields.

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.

Revised 2014 (Resolution 24)*

ACR–AIUM–SRU PRACTICE PARAMETER FOR THE PERFORMANCE OF VASCULAR ULTRASOUND FOR POSTOPERATIVE ASSESSMENT OF DIALYSIS ACCESS

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. For these reasons and those set forth below, the American College of Radiology and our collaborating medical specialty societies caution against the use of these documents in litigation in which the clinical decisions of a practitioner are called into question.

The ultimate judgment regarding the propriety of any specific procedure or course of action must be made by the practitioner in light of all the circumstances presented. Thus, an approach that differs from the guidance in this document, standing alone, does not necessarily imply that the approach was below the standard of care. To the contrary, a conscientious practitioner may responsibly adopt a course of action different from that set forth in this document when, in the reasonable judgment of the practitioner, such course of action is indicated by the condition of the patient, limitations of available resources, or advances in knowledge or technology subsequent to publication of this document. However, a practitioner who employs an approach substantially different from the guidance in this document is advised to document in the patient record information sufficient to explain the approach taken.

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

1 Iowa Medical Society and Iowa Society of Anesthesiologists v. Iowa Board of Nursing, ___ N.W.2d ___ (Iowa 2013) Iowa Supreme Court refuses to find that the ACR Technical Standard for Management of the Use of Radiation in Fluoroscopic Procedures (Revised 2008) sets a national standard for who may perform fluoroscopic procedures in light of the standard’s stated purpose that ACR standards are educational tools and not intended to establish a legal standard of care. See also, Stanley v. McCarver, 63 P.3d 1076 (Ariz. App. 2003) where in a concurring opinion the Court stated that “published standards or guidelines of specialty medical organizations are useful in determining the duty owed or the standard of care applicable in a given situation” even though ACR standards themselves do not establish the standard of care.
I. INTRODUCTION

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 among the 3 organizations and are addressed by each separately.

Hemodialysis access maintenance is an important health care concern. To improve the care of dialysis patients, the National Kidney Foundation established the Kidney Disease Outcomes Quality Initiative (K/DOQI) in 2000 and updated it in 2006 [1-3]. The project set recommendations for placement and monitoring of hemodialysis accesses.

The failure rate of hemodialysis access in the first year is high [4]. Clinical monitoring of access function is recommended to detect deterioration in function of the access before thrombosis occurs [5-7]. However, in grafts, a stenosis may be present in a significant number of patients with normal findings on clinical evaluation [8]. In one study, sensitivity of clinical examination for venous anastomotic stenosis was 57% [9]. In patients who have abnormal flow volumes, salvage procedures or surgical revision may lengthen the life of the access, but there is conflicting data in the literature [10-13]. In a data analysis of 40,132 CMS beneficiaries, the benefits of percutaneous intervention were greatest in patients with new access or low access flow rates [4]. Differences in flow within an arteriovenous fistula (AVF) versus graft must be considered, as there are different diagnostic criteria associated with these 2 access types. This practice parameter is intended to help physicians in the performance of hemodialysis monitoring by ultrasound, to ensure a high quality exam, and to promote further understanding of potential salvage options.

These practice parameters will address primarily upper extremity hemodialysis access. Although lower extremity hemodialysis grafts have a significant role in patients without usable upper extremity access, the Doppler diagnostic criteria for lower extremity graft evaluation are less well-defined.

II. INDICATIONS/CONTRAINDICATIONS

A. Indications for dialysis access ultrasound include, but are not limited to, the following:

1. Patients whose vascular access is unable to deliver a dialysis blood flow rate greater than 400 ml/min
2. Patients with development of persistent ipsilateral upper extremity edema or pain after access placement surgery or a hemodialysis session
3. Patients with prolonged immaturity (>6 weeks) of a surgically created AVF
4. Patients suspected of having a pseudoaneurysm, AVF or graft stenosis, perigraft soft-tissue infection, or adjacent fluid collection
5. Patients with decreased or absent thrill or abnormal bruit over fistula
6. Follow-up after revision of an immature fistula
7. Patients with signs of vascular steal (cold fingers or hand or other signs of distal limb ischemia)
8. Access collapse during hemodialysis
9. Prolonged bleeding (>20 minutes) from access needle sites after dialysis despite local pressure
10. Unexplained decrease in delivered dose of dialysis (Kt/V). Kt/V is the product of dialyzer clearance and time divided by volume of water in the patient.
11. Difficult cannulation
12. Thrombus aspiration
13. Elevated venous pressure greater than 200 mmHg on a 300 cc/min pump
14. Elevated recirculation time of 15% or greater

There are no absolute contraindications to performance of this examination, but there may be physical limitations that prevent a complete duplex examination, such as the presence of indwelling catheters, open wounds, recent surgery,
scar tissue or calcification especially in the regions of multiple puncture sites, severe edema, contractures, or other reasons for immobility.

III. QUALIFICATIONS AND RESPONSIBILITIES OF PERSONNEL

Each organization addresses this requirement individually. ACR language is as follows:

See the ACR–SPR–SRU Practice Parameter for Performing and Interpreting Diagnostic Ultrasound Examinations.

IV. WRITTEN REQUEST FOR THE EXAMINATION

Each organization addresses this requirement individually. ACR language is as follows:

The written or electronic request for postoperative dialysis access ultrasound 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 scope of practice requirements. (ACR Resolution 35, adopted in 2006)

V. SPECIFICATIONS OF THE EXAMINATION

The ultrasound examination for evaluating postoperative hemodialysis access is designed to detect abnormalities that may cause the access to thrombose, function poorly, not be accessible for dialysis, or produce undesired symptomatology in the arm.

It is important to understand the anatomic configuration of the dialysis access to enable accurate characterization of the usability of the access. Review of clinical records can be useful if there is history of documented variant anatomy or surgery such as failed fistulas or jump grafts. A forearm AVF directly connects an artery (usually radial) to a vein (usually cephalic) at the wrist or distal forearm to increase flow in the draining vein (forearm cephalic vein AVF). This allows dilatation and wall thickening in the vein for subsequent access to allow hemodialysis. An upper arm AVF can connect the brachial artery at the antecubital (AC) fossa to the cephalic vein (upper arm cephalic vein AVF) or to a transposed basilic vein (basilic vein transposed AVF). If AVF creation is not possible, graft configurations may include a forearm loop graft anastomosed to the brachial artery and antecubital vein at the AC fossa, an upper arm straight graft from the brachial artery at AC fossa to cranial basilic vein, or an upper arm loop graft anastomosed to the axillary artery and axillary vein.

Regardless of whether an examination is requested for failure to mature or dysfunction in a previously usable hemodialysis access, the components of the sonographic study of both AVFs and grafts are similar [14,15]. Copious ultrasound gel and careful attention to limit pressure applied by the transducer will minimize deformity of the vein, which may affect measurements of the vein diameter. Evaluation of inflow, outflow, turbulent or stenotic flow, outpouching, identification of large competing vein branches, and depth from the skin surface are basics of a hemodialysis access exam. Characterization of any collection near the access should be performed.

Note: For anatomic localization of an abnormality in the upper extremity venous structures, the words “cranial” and “caudal” are preferred since there is some uncertainty in the use of the terms “proximal” and “distal” with regards to the veins. Alternatively, the location of a draining vein stenosis may be described by its distance from the
anastomosis. The longitudinal, or long, axis is parallel to or along the length of the vein. Transverse, or short, axis is perpendicular to the long axis of the vein. For describing the location selected to measure the velocity that is used as the denominator in the peak velocity ratio of a stenosis, the terms “2 cm upstream” may be used. The artery supplying the anastomosis is commonly described as the “feeding artery” or “arterial inflow.”

A. Upper Extremity AVF Examination for Fistula Dysfunction

Sonographic evaluation of an AVF seeks to detect stenosis, which may limit flow within the AVF. The most common site of stenosis is the arteriovenous anastomosis [10,16]. The draining vein is another focus of the postoperative AVF ultrasound since it is the region that is accessed for hemodialysis, sometimes resulting in stenosis.

Initial evaluation to measure fistula diameter and to detect stenosis is performed with grayscale imaging. Using color and spectral Doppler in a long axis plane, the peak systolic velocity (PSV) at the anastomosis is compared to the PSV in the artery 2 cm upstream from the anastomosis. A PSV ratio (anastomosis/artery 2 cm upstream) greater than 3:1 has been suggested to represent a stenosis with diameter reduction greater than 50% [17,18]. However, the stenosis may be correlated with grayscale imaging since there is often sharp angulation of the venous origin at the anastomosis, which may simulate Doppler findings of stenosis.

Incorrect Doppler angle correction and incorrect Doppler settings can also contribute to measurement error [19]. The Doppler angle of insonation should be maintained ≤60 degrees and the angle correction cursor should be parallel to the vessel wall.

In addition to the area of the anastomosis, any visible narrowing of the draining vein on grayscale imaging or color aliasing of flow within the vein should be further assessed with velocity measurements by spectral Doppler. The PSV at the narrowing is compared to the PSV of the vein 2 cm upstream. A draining vein PSV ratio (narrowed draining vein/vein 2 cm upstream) greater than 2:1 suggests ≥50% stenosis, whether present in a patient with either AVF or graft [15]. If there is poor draining vein flow in the absence of anastomotic stenosis, the downstream (cranial) venous system may be stenotic or thrombosed. Assessment of spectral Doppler waveforms in the ipsilateral internal jugular vein and subclavian vein can suggest central stenosis, which may be further assessed with other imaging modalities.

An AVF must have adequate arterial inflow in order to mature and function [20]. The rate of arterial stenosis may be much higher in dysfunctional AVFs (40%) or grafts (29%) than in functional accesses, and more than half of patients with arterial stenosis have associated venous abnormalities [21]. Poststenotic arterial waveforms with parvus and tardus characteristics should be considered abnormal in the inflow vessel (feeding artery). The failure to document velocity elevation in the presence of lumen diameter reduction by B-mode may indicate inflow disease/stenosis or low systemic pressure. Fortunately, inflow stenosis is uncommon (5% of patients) in a newly created AVF [22,23].

The direction of arterial flow distal from the anastomosis of an AVF may be evaluated to determine if flow to the hand is reversed or bidirectional. Distal arterial steal is common in AVFs, although it is usually asymptomatic [24]. Symptoms of hand ischemia after AVF creation are more common in diabetics with arterial disease in the setting of previous failed AVFs [25]. Hand ischemia may occur for several reasons: inflow artery stenosis or occlusion, either in the feeding or a more proximal artery (such as the subclavian artery), outflow artery stenosis or occlusion, or excessive fistula flow. Ultrasound evaluation may assist in the diagnosis of each of these etiologies [26]. Alternatively, pulse-volume recordings (PVRs) of the upper extremities with and without access compression will provide an indication of adequacy of flow. Other nonstenotic abnormalities such as pseudoaneurysm, hematoma, and abscess can be diagnosed by a combination of grayscale and duplex Doppler ultrasound. Color Doppler should be used to evaluate any collection adjacent to the fistula.
B. Evaluation of AVF Failure to Mature

A large proportion (28% to 53%) of surgically created AVFs are not initially usable for hemodialysis [27-29]. The mature AVF must be easily palpable and allow cannulation by 2 17-gauge needles. If an adequate AVF is not clinically identified in the first 4 to 8 weeks after surgical access creation, ultrasound can be performed to detect a correctable anatomic problem.

The anastomosis is evaluated for stenosis using the same diagnostic criteria defined in the section above on upper extremity AVF examination for fistula dysfunction. Again, a greater than 3:1 PSV ratio of anastomosis compared with feeding artery 2 cm upstream should suggest anastomotic stenosis. Special attention is given to detect stenosis of the draining vein, using a 2:1 threshold ratio for stenosis.

Volumetric blood flow is measured in the midportion of the draining vein in a region of the vein that is straight and nontapering, without turbulent flow. The Doppler gate is adjusted to encompass the lumen of the vein with the alignment of the sample volume markers perpendicular to the venous walls. The angle of Doppler insonation for blood flow calculation is standardized at 60 degrees or less than 60 degrees to minimize the degree of measurement error. A sequence of 3 to 4 cardiac cycles is obtained to allow calculation of time-averaged velocities. The average of 3 to 5 measurements is reported [12].

If no stenosis is identified, thresholds for venous diameter and blood flow may suggest whether the AVF is mature for hemodialysis. An AVF with venous diameter of at least 4 to 6 mm and blood flow of at least 500 to 600 ml/min predicts an AVF that has a high likelihood of allowing successful hemodialysis [14,30]. The lower range of values may be chosen to reduce abandonment of a fistula that may subsequently mature and recognizes the measurement error in measuring flow volumes. A draining vein that is greater than 5 to 6 mm deep to the skin surface may mature but be too deep for consistent cannulation, and the draining vein in these situations may require superficialization.

Venous branches are noted and documented based on size and distance from anastomosis. In these patients, large draining venous branches (competing veins) may be surgically ligated to increase flow through the main draining vein to allow AVF maturation [31]. The venous drainage to the level of the medial subclavian vein may be evaluated if not done previously on a preoperative study, since downstream venous stenosis or thrombosis may inhibit AVF maturation.

C. Upper Extremity Examination for Graft Dysfunction

In a graft, the venous anastomosis is the most common location of stenosis. A PSV ratio (anastomosis/graft 2 cm upstream) greater than 2:1 is used as a threshold to diagnose a 50% stenosis at the venous anastomosis, and a 3:1 ratio suggests a 75% stenosis [8,15]. The arterial anastomosis of grafts has more variability in flow velocity relative to the upstream feeding artery than fistulas. A PSV ratio greater than 3:1 should raise concern for stenosis at the arterial anastomosis of a graft, but there is lower specificity than at other locations [15]. As part of a complete study, the graft should be inspected with grayscale, color, and spectral Doppler. PSV measurement at the mid graft should be obtained. Likewise, the draining vein in the limb cranial to the graft should be evaluated with color Doppler for signs of narrowing and/or aliasing. In regions of suspected narrowing in the draining vein of a graft, a PSV ratio should be calculated with a 2:1 threshold ratio applied for diagnosis of stenosis in a manner similar to the draining vein of an AVF. The sites of any stenoses are documented, and the length of stenosis is noted. A normal color Doppler examination is useful since it precludes the need for further imaging [32].

Normal blood flow volumes within grafts are commonly higher than AVFs, but even flow rates of 500 to 1,300 ml/min have been reported with graft stenosis. Blood flow less than 500 ml/min should lead to a fistulogram even if no anatomic etiology for the low blood flow is found.

The central veins of the chest can also be examined. In the absence of any other etiology for access dysfunction, the central veins of the chest should be evaluated, especially if there is reason to suspect central venous stenosis such as arm swelling, shoulder collaterals, or history of prolonged or multiple subclavian or internal jugular vein
catheterizations. In some patients, multiple stenoses may be present; persistent slow flow after treatment of an inflow stenosis may unmask a central abnormality. Close attention to detail is required since some central stenoses may be missed by sonographic evaluation [32].

Evaluation of the feeding artery should be performed in the same manner as for AVF evaluation described above. Reversal of flow in the distal artery may occur and is often asymptomatic, similar to patients with AVFs.

D. Routine Sonographic Monitoring of Functional Access

There is uncertainty, and even doubt, in the literature whether aggressive routine monitoring and angioplasty of a hemodialysis access, especially in a graft, can predict or affect subsequent thrombosis or cumulative patency [4,33-41].

VI. DOCUMENTATION

Each organization addresses this requirement individually. 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. 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 consistent both with clinical need and with relevant legal and local health care facility requirements.

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

VII. EQUIPMENT SPECIFICATIONS

The sonographic evaluation of the peripheral veins and arteries should include both real-time imaging of the veins and their contents and evaluation of the flow signals originating from within the lumen of the veins. 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 7 MHz or greater, with the occasional need for a lower frequency transducer, such as during insonation of the central veins. To determine flow rates, higher resolution transducers are needed, preferably 9 to 15 MHz. In most cases, a linear or curved linear transducer is preferable to obtain adequate images. The flow signals originating from within the lumen of the vein should be evaluated with a Doppler frequency of 2.5 MHz or above. A display of the relative amplitude and direction of moving blood should be available.

Imaging and flow analysis are currently performed with duplex sonography using range gating. Color Doppler is used to detect aliasing that is indicative of stenosis and facilitate the examination.

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

Each organization addresses this requirement individually. 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 Technical Standard for Diagnostic Medical Physics Performance Monitoring of Real Time Ultrasound Equipment.

ACKNOWLEDGEMENTS

This practice parameter was revised according to the process described under the heading The Process for Developing ACR Practice Parameters and Technical Standards on the ACR website (http://www.acr.org/guidelines) by the Committee on Practice Parameters – Ultrasound of the ACR Commission on Ultrasound in collaboration with the AIUM and the SRU.

Collaborative Subcommittee
Members represent their societies in the initial and final revision of this practice parameter.

ACR
Mark E. Lockhart, MD, MPH, Chair
Michelle L. Robbin, MD, FAcR

AIUM
Laurence Needleman, MD, FAcR
Victoria Teodorescu, MD, MBA
Franklin N. Tessler, MD, CM

SRU
Janis G. Letourneau, MD
John S. Pellerito, MD, FAcR
Leslie M. Scoutt, MD, FAcR

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

Beverly E. Hashimoto, MD, FAcR, Chair
Sandra O. DeJesus Allison, MD
Teresita L. Angtuaco, MD, FAcR
Marcela Bohm-Velez, MD, FAcR
Maria A. Calvo-Garcia, MD
Helena Gabriel, MD
Gail N. Morgan, MD
Maitray D. Patel, MD
Henrietta Kotlus Rosenberg, MD, FAcR
Sheila Sheth, MD, FAcR
Maryellen R.M. Sun, MD
Sharlene A. Teefey, MD, FAcR
Jason M. Wagner, MD

Deborah Levine, MD, FAcR, Chair, Commission on Ultrasound
Debra L. Monticciolo, MD, FAcR, Chair, Commission on Quality and Safety
Julie K. Timins, MD, FAcR, Chair, Committee on Practice Parameters and Technical Standards

Comments Reconciliation Committee
Jacqueline A. Bello, MD, FAcR, Chair
Kristen K. DeStigter, MD, FAcR, Co-Chair
Kimberly E. Applegate, MD, MS, FAcR
Beverly E. Hashimoto, MD, FAcR
William T. Herrington, MD, FAcR
Paul A. Larson, MD, FAcR
Janis G. Letourneau, MD
Deborah Levine, MD, FAcR
REFERENCES


*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
2007 (Resolution 28)
Revised 2014 (Resolution 24)