2007 (Resolution 28)*

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

PREAMBLE

These guidelines are an educational tool designed to assist practitioners in providing appropriate radiologic care for patients. They 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 cautions against the use of these guidelines 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 guidelines, 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 guidelines 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 guidelines. However, a practitioner who employs an approach substantially different from these guidelines 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 guidelines 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 these guidelines is to assist practitioners in achieving this objective.

I. INTRODUCTION

The clinical aspects contained in specific sections of this guideline (Introduction, Indications, Specifications of the Examination, and Equipment Specifications) were developed collaboratively by the American College of Radiology (ACR) and the American Institute of Ultrasound in Medicine (AIUM). Recommendations for physician requirements, written request for the examination, procedure documentation, and quality control vary between the two 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.

Clinical monitoring of access function is recommended to detect deterioration in function of the access before thrombosis occurs [4-6]. However, in grafts, a vascular stenosis may be present in a large proportion of patients with normal findings on clinical evaluation [7]. In patients

who have abnormal flow, salvage procedures or surgical revision may lengthen the life of the access [8-11]. Differences in flow within an arteriovenous fistula (AVF) versus graft must be considered, as there are different diagnostic criteria associated with these two access types. This guideline 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.

II. INDICATIONS/CONTRAINDICATIONS

Indications for dialysis access ultrasound include, but are not limited to:

1. Patients with decreased flow rates during hemodialysis.
2. Patients with development of arm swelling or discomfort after access placement surgery or a hemodialysis session.
3. Patients with prolonged immaturity of a surgically created AVF.
4. Patient suspected of having a pseudoaneurysm, AVF or graft stenosis, or adjacent fluid collection.

There are no absolute contraindications to performance of this exam.

III. QUALIFICATIONS AND RESPONSIBILITIES OF PERSONNEL

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

See the ACR–SPR–SRU Practice Guideline 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 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. 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 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 [12, 13]. Copious ultrasound gel and careful attention to limit pressure applied by the transducer will minimize deformity of the vein, which may especially affect measurements of the vein diameter. Evaluation of inflow, outflow, turbulent or stenotic flow, and identification of large competing vein branches are basics of a hemodialysis access exam.

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 [8,14]. 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 of fistula diameter and for stenosis is performed with grayscale imaging. Using color and spectral Doppler, 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% [15,16]. However, an attempt should be made to confirm the stenosis on grayscale imaging since there is often sharp angulation of the venous origin at the anastomosis; this may simulate stenosis.

Any visible narrowing of the 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 [13]. If there is poor draining vein flow in the absence of anastomotic stenosis, the downstream venous system may be stenotic or thrombosed. Assessment of spectral Doppler waveforms in the internal jugular vein and medial subclavian vein can predict central stenosis.

An AVF must have adequate arterial inflow in order to mature and function [17]. Poststenotic arterial waveforms with parvus and tardus characteristics should be considered abnormal. Fortunately, inflow stenosis is uncommon (5% of patients) in a newly created AVF [18]. The rate of periarterial stenosis may be much higher in dysfunctional AVFs (40%) or grafts (29%), and more than half have associated venous abnormalities [19]. The direction of flow downstream from the anastomosis of a forearm cephalic AVF should be evaluated to determine if flow is reversed. Distal arterial steal is common in AVFs, although it is usually asymptomatic [20]. Symptoms of hand ischemia after AVF creation are more common in diabetics with arterial disease in the setting of previous failed AVFs [21].

B. Evaluation of AVF Failure to Mature

A large proportion (28% to 53%) of surgically created AVFs are not initially usable for hemodialysis [22-24]. The mature AVF must be easily palpable and allow cannulation by two 17-gauge needles. If an adequate forearm 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, greater than 3:1 PSV ratio of anastomosis compared with feeding artery 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 straight, nontapering, nonturbulent vein. The Doppler gate is adjusted to encompass the lumen of the vein with the diameter perpendicular to the venous walls. The angle of Doppler insonation for blood flow calculation is standardized at 60 degrees or at least maintained less than 60 degrees. A sequence of three to four cardiac cycles is obtained to allow calculation of time-averaged velocities. The average of three to five measurements is calculated [10].

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 mm and blood flow of at least 500 ml/min predicts AVF that has a high likelihood to be usable for hemodialysis [12].

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 [25]. 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 50% stenosis at the venous anastomosis, and a 3:1 ratio suggests 75% stenosis [7,13]. The arterial anastomosis has more variability in flow velocity relative to the upstream artery than is commonly seen at an AVF anastomosis. 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 the venous anastomosis [13]. As part of a complete study, the flow within the graft should be visually inspected with grayscale, color and spectral Doppler. Measurement at the mid graft should be obtained. Likewise, the draining vein should be evaluated with color Doppler for signs of aliasing. In regions of aliasing in the draining vein of a graft, a PSV ratio should be calculated with a 2:1 threshold ratio applied, 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 exam, occurring in approximately one-third of moderate risk patients, is useful since it precludes the need for further imaging [26].

Varying amounts of blood flow, 500 to 1,300 ml/min, have been reported in association 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. Normal blood flow within a graft may be higher than is usual in AVFs.

The central veins of the chest can also be examined. In the absence of other etiology for AVF 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 vein catheterizations. Close attention to detail is required, since some central stenoses may be missed by sonographic evaluation [26].

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, as noted in AVFs, and is often asymptomatic.

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 [27-32].

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 healthcare facility requirements.

Reporting should be in accordance with the ACR Practice Guideline 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. For determination of 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 carrier 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 web page (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.

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Commission on Ultrasound in collaboration with the American Institute of Ultrasound in Medicine (AIUM).

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REFERENCES:

1. III. NKF-K/DOQI Clinical Practice Guidelines for Vascular Access: update 2000. *Am J Kidney Dis* 2001;37:S137-181.
2. (NIDDK) NIoDaDaKD. Kidney and urologic diseases statistics for hte United States: National Kidney and Urologic Diseases Information Clearinghouse (NKUDIC); 2001.
3. Foundation NK. KDOQI Clinical Practice Guidelines and Clinical Practice Recommendations for 2006 Updates: Hemodialysis adequacy, peritoneal dialysis adequacy and vascular access. *Am J Kidney Dis* 2006;48:S1-S322.
4. Besarab A, Sullivan KL, Ross RP, Moritz MJ. Utility of intra-access pressure monitoring in detecting and correcting venous outlet stenoses prior to thrombosis. *Kidney Int* 1995;47:1364-1373.
5. Cayco AV, Abu-Alfa AK, Mahnensmith RL, Perazella MA. Reduction in arteriovenous graft impairment: results of a vascular access surveillance protocol. *Am J Kidney Dis* 1998;32:302-308.
6. McCarley P, Wingard RL, Shyr Y, Pettus W, Hakim RM, Ikizler TA. Vascular access blood flow monitoring reduces access morbidity and costs. *Kidney Int* 2001;60:1164-1172.
7. Older RA, Gizienski TA, Wilkowski MJ, Angle JF, Cote DA. Hemodialysis access stenosis: early detection with color Doppler US. *Radiology* 1998;207:161-164.
8. Beathard GA, Arnold P, Jackson J, Litchfield T. Aggressive treatment of early fistula failure. *Kidney Int* 2003;64:1487-1494.
9. Roberts AB, Kahn MB, Bradford S, et al. Graft surveillance and angioplasty prolongs dialysis graft patency. *J Am Coll Surg* 1996;183:486-492.
10. Sands JJ, Jabyac PA, Miranda CL, Kapsick BJ. Intervention based on monthly monitoring decreases hemodialysis access thrombosis. *Asaio J* 1999;45:147-150.
11. Turmel-Rodrigues L, Pengloan J, Blanchier D, et al. Insufficient dialysis shunts: improved long-term patency rates with close hemodynamic monitoring, repeated percutaneous balloon angioplasty, and stent placement. *Radiology* 1993;187:273-278.
12. Robbin ML, Chamberlain NE, Lockhart ME, et al. Hemodialysis arteriovenous fistula maturity: US evaluation. *Radiology* 2002;225:59-64.
13. Robbin ML, Oser RF, Allon M, et al. Hemodialysis access graft stenosis: US detection. *Radiology* 1998;208:655-661.
14. Rajan DK, Bunston S, Misra S, Pinto R, Lok CE. Dysfunctional autogenous hemodialysis fistulas: outcomes after angioplasty--are there clinical predictors of patency? *Radiology* 2004;232:508-515.
15. Chao A, Daley T, Gruenewald S et al. Duplex ultrasound criteria for assessment of stenoses in radiocephalic hemodialysis fistulas. *Journal of Vascular Technology* 2001;6:203-208.
16. Lockhart ME, Robbin ML. Hemodialysis access ultrasound. *Ultrasound Q* 2001;17:157-167.
17. Obialo CI, Tagoe AT, Martin PC, Asche-Crowe PE. Adequacy and survival of autogenous arteriovenous fistula in African American hemodialysis patients. *Asaio J* 2003;49:435-439.
18. Grogan J, Castilla M, Lozanski L, Griffin A, Loth F, Bassiouny H. Frequency of critical stenosis in primary arteriovenous fistulae before hemodialysis access: should duplex ultrasound surveillance be the standard of care? *J Vasc Surg* 2005;41:1000-1006.
19. Asif A, Gadalean FN, Merrill D, et al. Inflow stenosis in arteriovenous fistulas and grafts: a multicenter, prospective study. *Kidney Int* 2005;67:1986-1992.
20. Sivanesan S, How TV, Bakran A. Characterizing flow distributions in AV fistulae for haemodialysis access. *Nephrol Dial Transplant* 1998;13:3108-3110.
21. Sessa C, Pecher M, Maurizi-Balzan J, et al. Critical hand ischemia after angioaccess surgery: diagnosis and treatment. *Ann Vasc Surg* 2000;14:583-593.

22. Allon M, Lockhart ME, Lilly RZ, et al. Effect of preoperative sonographic mapping on vascular access outcomes in hemodialysis patients. *Kidney Int* 2001;60:2013-2020.
23. Miller PE, Tolwani A, Luscy CP, et al. Predictors of adequacy of arteriovenous fistulas in hemodialysis patients. *Kidney Int* 1999;56:275-280.
24. Won T, Jang JW, Lee S, Han JJ, Park YS, Ahn JH. Effects of intraoperative blood flow on the early patency of radiocephalic fistulas. *Ann Vasc Surg* 2000;14:468-472.
25. Beathard GA, Settle SM, Shields MW. Salvage of the nonfunctioning arteriovenous fistula. *Am J Kidney Dis* 1999;33:910-916.
26. Dumars MC, Thompson WE, Bluth EI, Lindberg JS, Yoselevitz M, Merritt CR. Management of suspected hemodialysis graft dysfunction: usefulness of diagnostic US. *Radiology* 2002;222:103-107.
27. Dember LM, Holmberg EF, Kaufman JS. Value of static venous pressure for predicting arteriovenous graft thrombosis. *Kidney Int* 2002;61:1899-1904.
28. Dember LM, Holmberg EF, Kaufman JS. Randomized controlled trial of prophylactic repair of hemodialysis arteriovenous graft stenosis. *Kidney Int* 2004;66:390-398.
29. Malik J, Slavikova M, Svobodova J, Tuka V. Regular ultrasonographic screening significantly prolongs patency of PTFE grafts. *Kidney Int* 2005;67:1554-1558.
30. Robbin ML, Oser RF, Lee JY, Heudebert GR, Mennemeyer ST, Allon M. Randomized comparison of ultrasound surveillance and clinical monitoring on arteriovenous graft outcomes. *Kidney Int* 2006;69:730-735.
31. Shahin H, Reddy G, Sharafuddin M, Katz D, Franzwa BS, Dixon BS. Monthly access flow monitoring with increased prophylactic angioplasty did not improve fistula patency. *Kidney Int* 2005;68:2352-2361.
32. White JJ, Bander SJ, Schwab SJ, et al. Is percutaneous transluminal angioplasty an effective intervention for arteriovenous graft stenosis? *Semin Dial* 2005;18:190-202.

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