AIUM Practice Parameter for the Performance of

Ultrasound Vascular Mapping for Preoperative Planning of Dialysis Access

Parameter developed in collaboration with the American College of Radiology and the Society of Radiologists in Ultrasound.

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The American Institute of Ultrasound in Medicine (AIUM) is a multidisciplinary association dedicated to advancing the safe and effective use of ultrasound in medicine through professional and public education, research, development of parameters, and accreditation. To promote this mission, the AIUM is pleased to publish, in conjunction with the American College of Radiology (ACR) and the Society of Radiologists in Ultrasound (SRU), this AIUM Practice Parameter for the Performance of Ultrasound Vascular Mapping for Preoperative Planning of Dialysis Access. We are indebted to the many volunteers who contributed their time, knowledge, and energy to bringing this document to completion.

The AIUM represents the entire range of clinical and basic science interests in medical diagnostic ultrasound, and, with hundreds of volunteers, the AIUM has promoted the safe and effective use of ultrasound in clinical medicine for more than 50 years. This document and others like it will continue to advance this mission.

Practice parameters of the AIUM are intended to provide the medical ultrasound community with parameters for the performance and recording of high-quality ultrasound examinations. The parameters reflect what the AIUM considers the minimum criteria for a complete examination in each area but are not intended to establish a legal standard of care. AIUM-accredited practices are expected to generally follow the parameters with recognition that deviations from these parameters will be needed in some cases, depending on patient needs and available equipment. Practices are encouraged to go beyond the parameters to provide additional service and information as needed.
I. Introduction

The clinical aspects contained in specific sections of this parameter (Introduction, Indications/Contraindications, Specifications of the Examination, and Equipment Specifications) were developed collaboratively by the American Institute of Ultrasound in Medicine (AIUM), the American College of Radiology (ACR), 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.

Mapping of arm vessels before surgical creation of dialysis access has been shown to be useful in helping achieve a higher percentage of arteriovenous fistula (AVF) placements as well as an increased fistula success rate.1-6

This practice parameter is intended to help physicians in the performance of preoperative mapping, to guarantee a high-quality examination, and to help promote successful placement of the most preferred types of dialysis access. Kidney Disease Outcomes Quality Initiative (K/DOQI) guidelines7 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 usually preferable for dialysis access placement and is usually evaluated first. A forearm AVF is preferred over an upper arm AVF. A dominant forearm AVF may be preferred over a nondominant upper arm AVF, depending on surgical preference.
2. A forearm cephalic vein AVF (radial artery–cephalic vein), followed by an upper arm cephalic vein AVF (brachial artery–cephalic vein), is preferred.
3. If it is not possible to create either of these fistulae, 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).
4. If the vascular anatomy is not suitable for AVF placement, a graft of synthetic material (eg, polytetrafluoroethylene [PTFE]) may be placed. A forearm loop graft (brachial artery to antecubital vein) is preferred over an upper arm straight graft (brachial artery to basilic vein). 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 grafts (superficial femoral artery to great saphenous vein or common femoral vein) are the next usual site for access placement.8,9
6. Placement of an upper extremity AVF or an arm or thigh graft is preferred to catheter-based hemodialysis due to increased catheter infection rates and often lower catheter flow rates compared to a graft or fistula.10

II. Indications/Contraindications

Indications for vascular mapping for preoperative planning of dialysis access include planning of vascular access for hemodialysis. There are no absolute contraindications for this examination.
III. Qualifications and Responsibilities of Personnel

See www.aium.org for AIUM Official Statements including *Standards and Guidelines for the Accreditation of Ultrasound Practices* and relevant Physician Training Guidelines.11

IV. Written Request for the Examination

The written or electronic request for an ultrasound examination should provide sufficient information to allow for the appropriate performance and interpretation of the examination.

The request for the examination must be originated by a physician or other appropriately licensed health care provider or under the provider’s direction. The accompanying clinical information should be provided by a physician or other appropriate health care provider familiar with the patient’s clinical situation and should be consistent with relevant legal and local health care facility requirements.

V. Specifications of the Examination

The ultrasound examination for dialysis access planning is designed to gather information about both the arterial system and the venous system. It is important to understand the procedure and surgical techniques to be used by the local dialysis access surgeon(s) to obtain information tailored to the technique. Both arms can be mapped in their entirety, or a more focused preoperative mapping can be performed that concludes when vessels adequate for AVF formation are found.

A. Arterial Examination

The examination is done either on both arms or only on one arm, depending on laboratory preference. If a unilateral examination is chosen, the nondominant arm is examined first unless there is a known contraindication to the use of this arm. The artery used must be of sufficient size (diameter >0.20 cm)4,12 to construct the fistula and to have adequate flow for maturation. This size may vary according to surgical preference. The artery is first evaluated with gray scale and spectral Doppler imaging. The internal luminal diameter of the artery is measured at the level of expected fistula creation. The presence of calcification is recorded and reported because the surgical anastomosis can be difficult if significant concentric calcification is present. Arterial spectral waveforms should be assessed to screen for inflow or outflow disease.

For a forearm AVF, the 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 graft creation, the brachial artery is assessed at the antecubital fossa for the 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 which occurs in approximately 10% of patients.13 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 because some surgeons will place an AVF, but not a graft, below 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 imaging. Reversal of blood flow distal to the proximal occlusion confirms patency of the palmar arch.\textsuperscript{14}

B. Venous Examination

The nondominant arm is examined first unless there is a known contraindication to the use of that arm. The examination is focused first toward finding a vein suitable for AVF creation. If no suitable vein is found, veins suitable for graft creation are sought.

The vein mapped to receive the arterial anastomosis should be measured after it is dilated. This measurement will more closely approximate the size of the arterialized vein after fistula formation. The vein is generally dilated by use of sequential tourniquet placement or an inflated blood pressure cuff on the arm.\textsuperscript{15} 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 line. Other suitable dorsal or volar caudal forearm veins may be identified with this technique.

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 third of the forearm. The cephalic vein is imaged at the site of the expected anastomosis at the wrist. It is assessed for compressibility, thrombus, and size. Measurements are obtained with a minimal diameter of 0.25 cm for all veins used for an AVF.\textsuperscript{4,12} There may be variations in the diameter used based on clinical factors or surgical preference. The vein diameter is measured at the caudal, mid, and cranial forearm; at the antecubital fossa; and at the caudal, mid, and cranial upper arm, as applicable. The sites and length of any venous stenosis are noted. Veins that are borderline in size (within 0.05 cm of the desired size) are measured again after more focused percussion or after application of a warm compress for several minutes. If a sclerotic or thick-walled vein is seen, the diameter measured should be the inner luminal diameter and the abnormality noted.

The cephalic vein should be evaluated throughout the entire arm to its insertion into the subclavian vein. Focal narrowing of the vein at any level may preclude successful maturation of a created fistula. Note that the forearm cephalic vein may drain preferentially via a large antecubital vein into the basilic or brachial veins if the upper arm cephalic vein is too small or thrombosed. In this case, placement of a forearm fistula is still possible as long as diameter thresholds are maintained.

Veins must be relatively superficial to be easily cannulated after placement of a fistula. The depth from the skin surface to the cephalic veins of adequate diameter may be measured to assess the need for a subsequent superficialization procedure.\textsuperscript{16}

If the cephalic vein in the forearm is inadequate for fistula creation, other veins in the forearm may be examined to determine whether they are adequate. These veins in general will need to...
be transposed to a more easily accessible position in the anterior surface of the forearm. If no suitable vein is found in the forearm, the veins in the upper arm should be evaluated.

The upper arm cephalic vein should be examined for upper arm fistula creation. If it is too small or thrombosed, the basilic vein is evaluated. The basilic vein needs to be of adequate size for at least 4 cm in length, caudal to the antecubital fossa or 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 is needed for grafts.4

Similar assessment techniques should be used for all veins (ie, vein dilatation before insonation, demonstration of adequate size and normal venous compressibility, and determination of adequate venous drainage).

Large branches of veins near the site of a fistula can result in nonmaturation of the fistula.17-18 The sites and sizes of vein branches may be noted.

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 gray scale, spectral, and color Doppler imaging. Unilateral or bilateral monophasic waveforms or low-velocity venous waveforms are abnormal.19,20 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, computed tomography, or conventional venography if access placement on that side is desired.

**VI. Documentation**

Adequate documentation is essential for high-quality patient care. There should be a permanent record of the ultrasound examination and its interpretation. Images of all appropriate areas, both normal and abnormal, should be recorded. Variations from normal size should be accompanied by measurements. Images should be labeled with the patient identification, facility identification, examination date, and side (right or left) of the anatomic site imaged. An official interpretation (final report) of the ultrasound findings should be included in the patient’s medical record. Retention of the ultrasound examination should be consistent both with clinical needs and with relevant legal and local health care facility requirements.

Reporting should be in accordance with the *AIUM Practice Parameter for Documentation of an Ultrasound Examination.*21
VII. Equipment Specifications

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 imaging. 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 greater. 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 central stenosis is suspected from abnormal subclavian and internal jugular vein waveforms. Images of the relevant gray scale, color, and spectral Doppler waveforms should be recorded and archived. Color Doppler imaging 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 control, patient education, infection control, and safety should be developed and implemented in accordance with the AIUM Standards and Guidelines for the Accreditation of Ultrasound Practices.22 Equipment performance monitoring should be in accordance with the AIUM Standards and Guidelines for the Accreditation of Ultrasound Practices.22

IX. ALARA Principle

The potential benefits and risks of each examination should be considered. The ALARA (as low as reasonably achievable) principle should be observed when adjusting controls that affect the acoustic output and by considering transducer dwell times. Further details on ALARA may be found in the AIUM publication Medical Ultrasound Safety, Third Edition.

Acknowledgments

This parameter was revised by the American Institute of Ultrasound in Medicine (AIUM) in collaboration with the American College of Radiology (ACR) and the Society of Radiologists in Ultrasound (SRU) according to the process described in the AIUM Clinical Standards Committee Manual.

Collaborative Committee

Members represent their societies in the initial draft and final revision of this parameter.
References


