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ACR–AIUM–SRU PRACTICE PARAMETER FOR THE PERFORMANCE OF ULTRASOUND VASCULAR MAPPING FOR PREOPERATIVE PLANNING 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[1] 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, 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.

Mapping of arm vessels prior to 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 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) guidelines [7] 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, abbreviated 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 as 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

Core Privileging: This procedure is considered part of or amendable to image-guided core privileging.

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

See the ACR–SPR–SRU Practice Parameter for Performing and Interpreting Diagnostic Ultrasound Examinations [11].

IV. WRITTEN REQUEST FOR THE EXAMINATION

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

The written or electronic request for a dialysis access ultrasound examination should provide sufficient information to demonstrate the medical necessity of the examination and allow for its proper performance and interpretation.

Documentation that satisfies medical necessity includes 1) signs and symptoms and/or 2) relevant history (including known diagnoses). Additional information regarding the specific reason for the examination or a provisional diagnosis would be helpful and may at times be needed to allow for the proper performance and interpretation of the examination.

The request for the examination must be originated by a physician or other appropriately licensed health care provider. The accompanying clinical information should be provided by a physician or other appropriately licensed health care provider familiar with the patient's clinical problem or question and consistent with the state's scope of practice requirements. (ACR Resolution 35, adopted in 2006)

V. SPECIFICATIONS 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) in order 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 1 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 grayscale 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 since 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 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, as 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. Reversal of blood flow distal to the proximal occlusion confirms patency of the palmar arch [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 towards 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 following fistula formation. The vein is generally dilated by use of sequential tourniquet placement or an inflated blood pressure cuff on the arm [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 IV. 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 one-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 [4,12]. There may be variations in the diameter used based on clinical factors or surgical preference. 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 [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 prior to 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 grayscale, spectral, and color Doppler. 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 (MRI), computed tomography (CT), or conventional venography if access placement on that side is desired.

VI. DOCUMENTATION

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

Adequate documentation is essential for high-quality patient care. There should be a permanent record of the ultrasound examination and its interpretation. Comparison with prior relevant imaging studies may prove helpful. Images of all appropriate areas, both normal and abnormal, should be recorded. Variations from normal size should generally be accompanied by measurements. The initials of the operator should be accessible on the images or electronically on PACS. Images should be labeled with the patient identification, facility identification, examination date, and image orientation. An official interpretation (final report) of the ultrasound examination should be included in the patient's medical record. Retention of the ultrasound examination images should be based on clinical need and relevant legal and local health care facility requirements.

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

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

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

Equipment performance monitoring should be in accordance with the ACR Technical Standard for Diagnostic Medical Physics Performance Monitoring of Real Time Ultrasound Equipment [22].

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