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## **ACR–SIR PRACTICE PARAMETER FOR ENDOVASCULAR MANAGEMENT OF THE THROMBOSED OR DYSFUNCTIONAL DIALYSIS ACCESS**

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### **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<sup>1</sup> 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.

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<sup>1</sup>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

This practice parameter was revised collaboratively by the American College of Radiology (ACR) and the Society of Interventional Radiology (SIR).

Endovascular management of hemodialysis access prosthetic grafts and autogenous fistulae is an alternative treatment to surgical thrombectomy and revision [1,2]. It applies to accesses that have never matured, accesses that have thrombosed, accesses that have blood flow insufficient to allow hemodialysis, accesses with clinical symptoms or noninvasive assessments that indicate the access is at increased risk of thrombosis, and access complications such as pseudoaneurysm or steal. Successful thrombectomy procedures can be performed using pharmacologic thrombolysis [3-9], aspiration thrombectomy [10], mechanical thrombectomy [7,10-12], balloon thrombectomy [13,14], or combinations of these methods. A complete thrombectomy procedure includes angiography of the graft or fistula with evaluation of the arterial inflow as well as venography of the draining veins to the level of the superior vena cava–right atrial junction. Angiography can be performed with either conventional film screen [15] or digital subtraction techniques [16]. By these means, stenoses are located that can be the anatomic cause of access failure or reduced function. Restoration of a functional luminal diameter can be achieved with balloon angioplasty [3,4,8,13,17-23] and, in some cases, endovascular stents [21,24-30]. These procedures frequently are the initial treatment for a thrombosed or dysfunctional hemodialysis access; transluminal angioplasty is the preferred initial treatment of central vein stenosis to resolve upper extremity edema or relieve access dysfunction [1].

Endovascular management results in reduced morbidity compared to standard surgical therapy, with less postprocedure pain and **decreased** wound edema. Endovascular management of the thrombosed or dysfunctional hemodialysis access (EMDA) is usually performed on an outpatient basis, with the patient returning home or to the dialysis unit for treatment.

Subsequently, if the clinical and hemodynamic parameters become abnormal, the patient should undergo re-evaluation of the vascular access to identify recurrent stenosis requiring additional intervention [1].

Appropriate endovascular management of dysfunctional vascular access for hemodialysis includes:

- Determination of the procedural indication
- Assessment of the patient and physical evaluation of the vascular access
- Thorough angiographic evaluation of the vascular access circuit
- Identification and treatment of hemodynamically significant stenoses
- Determination of the technical success of the procedure

The preprocedural abnormal clinical parameters should normalize following a successful intervention. The outcome measures or indicators for these processes are indications, success rates, and complication rates. Outcome measures are assigned threshold levels.

## II. DEFINITIONS

For the purposes of this practice parameter, the following definitions apply:

Thrombosed hemodialysis access: an autogenous fistula or prosthetic graft/biologic graft that has no significant blood flow. The thrombus may extend into the runoff veins or the arterial-venous anastomosis. Autogenous fistulae, particularly those with aneurysmal segments, may harbor significantly larger amounts of thrombus than prosthetic grafts. The diagnosis of a thrombosed access is most frequently made by physical examination.

Dysfunctional hemodialysis access: a) an access with an abnormal hemodynamic or clinical indicator precluding effective dialysis and b) an autogenous fistula that has failed to mature during an adequate time period, or c) an access that cannot be successfully punctured to perform dialysis.

Functionally significant stenosis: an anatomically significant stenosis (>50% reduction of normal vessel diameter) accompanied by a hemodynamic or clinical abnormality such as:

1. Change in physical examination characteristics of the thrill
2. Elevated venous pressures recorded during hemodialysis (static and dynamic pressures) or measured within the vascular access during a diagnostic study (static pressures)
3. Detection of decreased intra-access blood flow at dialysis
4. Swollen extremity
5. Unexplained reduction in dialysis kinetics
6. Clinical parameters such as prolonged bleeding after needle withdrawal, altered physical examination characteristics of vascular access, or thrombosis
7. Elevated negative arterial prepump pressures that prevent increasing to acceptable blood flow
8. Inability to puncture to perform hemodialysis
9. Abnormal recirculation values [1]

Note: Prospective trend analysis is more valuable than isolated abnormalities in the above hemodynamic and clinical parameters. Abnormalities should be persistent over time to prompt treatment of the access.

Anatomically significant stenoses include:

1. Inflow problems
  - a. Stenosis of the inflow artery to the access, including central arterial stenosis, such as a brachiocephalic, subclavian, or axillary arterial stenosis
  - b. Stenosis at the anastomotic site of an autogenous fistula
  - c. Stenosis at the juxta-anastomotic segment of an autogenous fistula
  - d. Stenosis at the arterial anastomosis of synthetic grafts
2. Access problems
  - a. Stenosis of the hypertrophied venous segment of an autogenous fistula
  - b. Intragraft stenosis within prosthetic grafts
  - c. The great majority of anatomic causes are intrinsic to the graft or vessel. Rarely, however, extrinsic compression can contribute to access dysfunction (eg, prosthetic graft kinking, pseudoaneurysm compression of the access, or compression from a periaccess hematoma).
3. Outflow problems
  - a. Stenoses of the venous runoff from the venous anastomosis to the central veins
  - b. Failure to mature. In the case of the autogenous fistula, multiple venous runoff channels that divert blood flow away from the primary outflow vein can prevent the development of a hypertrophied outflow vein suitable for puncture [1].
  - c. Venous anastomotic stenosis of prosthetic grafts
  - d. Central vein stenosis that may occur following the placement of a central venous catheter ipsilateral to the site of the access. These can also be caused by fibrous bands, clavicular fractures, pacemaker wires, etc.

Note: Although >90% of access thromboses and dysfunction are due to underlying anatomic stenoses, a physiologic process such as low cardiac output, postdialysis hypotension, access site infection, dehydration, or a hypercoagulable state can result in thrombosis of a prosthetic graft or autogenous fistula in the absence of an anatomic cause or can have a synergistic effect with an anatomic stenosis to accelerate failure of the hemodialysis access.

Fistulogram: a specific type of angiogram to evaluate an autogenous fistula or prosthetic graft used as vascular access for hemodialysis treatment. A fistulogram should include imaging the entire vascular access circuit,

including the arterial anastomosis, the fistula or graft, the runoff veins, the ipsilateral central veins, and the superior/inferior vena cava. Oblique projections are often needed to optimize visualization and characterization of arterial and venous stenoses. Evaluation of the inflow arteries may be necessary when hemodynamic indicators or clinical symptoms are not explained by fistulography.

EMDA (endovascular management of the thrombosed or dysfunctional hemodialysis access): the use of catheter-based endovascular techniques to restore or maintain adequate blood flow within an access to support effective hemodialysis [1,31].

Endovascular thrombus removal: the removal of an occlusive thrombus from within the graft or fistula, including the outflow veins and inflow arteries, to restore blood flow to the access. Removal of the thrombus may be accomplished by any of several catheter-directed methods, such as thrombolysis, aspiration thrombectomy, balloon thrombectomy, clot maceration, and mechanical thrombectomy devices.

Endovascular treatment of a stenosis: the restoration of an acceptable luminal diameter to the segment (anatomic success) and resolution of the functional abnormality [1]. The stenosis may be treated with balloon angioplasty. In selected instances, stents, stent grafts, or cutting balloons may be required to improve luminal dimensions or repair a vascular injury. Prospective intervention is currently warranted for anatomical stenoses found in hemodialysis accesses and draining veins that also have an associated hemodynamic or clinical abnormality [1,31].

Anatomic success of a treated stenosis: restoration of luminal diameter with <30% residual diameter stenosis. For treatment of thrombosed accesses, both restoration of flow and <30% residual diameter stenosis for any significant underlying stenosis are required to report anatomic success [32,33]. However, several studies have reported that there is poor correlation between the degree of stenosis and the rate of blood flow through a prosthetic graft [34-36]. Depending on the rate of blood flow through the vascular access and the location of the treated lesion, a 30% or more residual stenosis may be hemodynamically significant.

Clinical success: the resumption of normal hemodialysis for a minimum of at least 1 session. After treatment of a stenosis, clinical success is defined as the improvement of clinical and hemodynamic parameters. After treatment of either a thrombosed access or an access-related stenosis, a continuous palpable thrill with minimal or no pulsatility extending from the arterial anastomosis can be considered one indicator of clinical success [32,33,37]. Physical examination of the access has the advantage of being easily performed in the interventional suite, unlike most of the monitoring tests.

Hemodynamic success: the restoration of hemodynamic parameters. Increase of volume flows to above predefined threshold values or reduction of venous dialysis or static pressures to below predefined threshold values can be considered evidence of hemodynamic success. Blood flow rates are not universally available in interventional suites [38] or dialysis clinics but have been correlated with degree of stenosis for a single lesion [35]. Static pressures are easily obtained in the interventional suite at minimal additional cost (transducer, tubing) but need to be interpreted in the context of their known limitations. It is the true intra-access static pressure that correlates with the degree of stenosis. Therefore, a reduction of the ratio between static intragraft venous limb systolic pressure and cuffed brachial systolic pressure to below predefined thresholds can be considered evidence of hemodynamic success.

Measurement of intragraft pressures to determine the hemodynamic significance of stenoses has been described by Sullivan and Besarab (see Appendix A). This study used a ratio of 0.4 to give 91% sensitivity for identifying synthetic access graft stenoses of at least 50% [39]. However, there are currently no uniformly accepted criteria of percent reduction from pretreatment values to determine hemodynamic success [37]. Further, accesses with high intra-access volume flows frequently have high venous systolic pressure ratios and no venous outflow lesions [40]. Some have questioned the use of pressures as an endpoint [32].

Procedural success: anatomic success and at least 1 indicator of hemodynamic or clinical success [32,33]

Postintervention primary patency: uninterrupted patency after intervention until the next access thrombosis or reintervention. Primary patency ends with treatment of a lesion anywhere within the access circuit, from the arterial inflow to the superior vena cava–right atrial junction [32,33].

Postintervention assisted primary patency (APP): patency following intervention until access thrombosis or a

surgical intervention that excludes the treated lesion from the access circuit. Percutaneous treatments of restenosis or a new arterial or venous outflow stenosis/occlusion (excluding access thrombosis) are compatible with APP. APP ends with percutaneous thrombolysis/thrombectomy or simple surgical thrombectomy [32].

Postintervention secondary patency: patency until the access is surgically declotted, revised, or abandoned because the patient undergoes renal transplant, is lost to follow-up, etc. Thrombolysis and percutaneous thrombectomy are compatible with secondary patency, as are multiple repetitive treatments [32].

Cumulative patency rate (CP): the total time that the access remains patent (regardless of the number of primary interventions and/or thrombectomies) during the given time period. CP begins at the time that the graft is first placed [1].

Postintervention lesion patency: the interval following intervention until the next reintervention at or adjacent to the original treatment site or until the extremity is abandoned for permanent access because of surgeon's choice, transplant, loss of follow-up, etc. Endovascular or surgical treatments of other lesions in the access circuit and creation of a new prosthetic graft or autogenous fistula that incorporates the original lesion into the access circuit are compatible with lesion patency.

Mature arteriovenous fistula: a fistula suitable for use when the diameter of a vein is sufficient to allow successful cannulation 4 to 6 weeks after construction [1].

Steal syndrome: ipsilateral extremity ischemia symptoms [41] in the presence of a functional graft or fistula. Etiologies include atherosclerotic arterial stenosis [42], diffuse disease in the native arteries of the extremity, and excessive blood flow through the fistula or graft [43]. High-flow fistulae with 20% to 50% of the cardiac output shunted through the access [44] can also result in cardiac overload [43].

### III. INDICATIONS

A. Indications for EMDA include, but are not limited to:

1. Stenoses without thrombosis occurring in a hemodialysis graft or fistula if the stenosis is >50% reduction in luminal diameter and is considered functionally significant (see definitions above). The percent stenosis reported can vary considerably depending on the reference chosen, that is, the smaller graft or vein upstream to the lesion (relative to direction of blood flow) versus a larger vein downstream (relative to direction of blood flow). Percent stenosis may also be affected by the presence or absence of blood flow in the access at the time of measurement [32].
2. Stenosis associated with thrombosis. Thrombosis is associated with underlying venous stenosis in >85% of cases [8].
3. Central vein stenosis >50% lumen reduction, when the vascular access is hemodynamically compromised and clinical parameters such as arm swelling or frequently failing access are present. Endovascular intervention with transluminal angioplasty is the preferred treatment of central vein stenosis [1].
4. Autogenous fistulae that have failed to mature after 4 to 6 weeks. Treatments include:
  - a. Balloon angioplasty of the inflow artery, arteriovenous anastomosis, juxta-anastomotic segment, or outflow segments to increase blood flow to the native vein. Multiple areas of stenoses may exist in nonmaturing fistulae [45-50].
  - b. Interruption of venous tributaries that divert blood flow from the primary venous segment improves blood flow and thereby promotes maturation of the fistula [45,46,48,51].

## B. Indications for Endoluminal Stent Placement

Several studies have demonstrated acceptable patencies for stent deployment following **unsuccessful** balloon angioplasty, especially for central vein lesions [24,25,52,53]. However, several prospective, randomized trials have failed to show a benefit of bare stents over percutaneous transluminal angioplasty alone in the treatment of perianastomotic stenoses [26,54]. Current indications for endoluminal stent placement include:

1. Persistence of a significant venous stenosis that has failed balloon angioplasty and surgical access is difficult, surgery is contraindicated, or there are limited remaining access sites
2. A significant central vein stenosis that has either failed balloon angioplasty or recurred within a 3- month period following an initially successful balloon angioplasty [1]
3. Rupture of an outflow vein following balloon angioplasty that cannot be controlled with balloon tamponade

The threshold for these indications is 95%. When <95% of procedures are for these indications, the department will review the process of patient selection.

Stent grafts may provide longer patency than bare stents for the venous anastomosis of grafts. Prospective, randomized, multicenter studies show better primary target lesion and circuit patencies after stent graft placement at the venous anastomosis of grafts and fistulas and in stent restenosis than after angioplasty alone [55,56]. Stent grafts have also been used to treat intra-access pseudoaneurysms in case reports and small series.

## C. Indications for Treatment of Steal

Steal can manifest by cardiac failure [43] or ischemic symptoms, including paresthesias, pain, motor weakness, sensory loss, or tissue loss. When ischemic symptoms occur in the presence of an atherosclerotic stenosis in the native arterial supply to the extremity, arterial angioplasty can relieve the symptoms [42]. When there is no arterial lesion, decreasing the flow in the graft or fistula by placing a flow-restricting band across the access near the arterial anastomosis can also improve or relieve symptoms of steal. Because of access thrombosis complications after surgical banding [57], a modified banding technique using an inflated angioplasty balloon to accurately size the residual lumen has been used [47]. A more complicated surgical procedure known as distal revascularization with interval ligation (DRIL) can also relieve symptoms. It involves ligation of the artery just distal to the anastomosis of the autogenous fistula or prosthetic graft and an arterial bypass from the artery proximal to the arteriovenous anastomosis to the artery distal to the ligation. DRIL has a low reported rate of access thrombosis [58]. Radiocephalic fistulae complicated by steal have been treated by distal radial artery occlusion, either ligation [59] or endovascular occlusion [60].

Current indications for treatment of steal include:

1. Clinical symptoms or signs of steal ipsilateral to a functional fistula or graft
2. High-flow fistula with signs or symptoms of heart failure

## IV. CONTRAINDICATIONS

The decision to treat a hemodialysis access with endovascular techniques is always made in light of the patient's clinical condition, the number of alternative access sites available, and the expertise of the treating physician.

### A. Absolute Contraindication

Active infection of the vascular access

## B. Relative Contraindications

1. Severe contrast allergy
2. Severe hyperkalemia, acidosis, or other life-threatening abnormality of blood chemistry that requires immediate dialysis
3. Known right-to-left shunt
4. Severe cardiopulmonary disease

## V. QUALIFICATIONS AND RESPONSIBILITIES OF PERSONNEL

Collaboration of the interventional radiologist with the hemodialysis vascular access team is an integral component of percutaneous hemodialysis access management. This practice parameter supports the statement of the National Kidney Foundation Dialysis Outcomes Quality Initiative (NKF/DOQI) that “Management of vascular access complications relies on a multidisciplinary approach involving nephrologists, nephrology nurses, vascular interventionists, and surgeons. The goal of these management efforts is the preservation of vascular access” [1]. Regularly scheduled multidisciplinary conferences are one possible approach to ensuring optimum care of patients with vascular access complications.

### A. Physician

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

Image-based diagnosis and treatment planning requires integrating the angiographic findings within the context of the patient’s history, physical findings, and prior imaging studies. Therefore, the physician must understand the specific clinical indication for the procedure in order to plan and perform it safely and effectively.

The physician performing EMDA must fully appreciate the benefits, alternatives, and risks of the procedure. He/she must have a thorough understanding of anatomy (including congenital and developmental variants and common collateral pathways), angiographic equipment, radiation safety, and physiologic monitoring equipment. The physician should have access to adequate supplies and personnel to perform the procedure safely.

EMDA must be performed under the supervision of and interpreted by a physician who has the following qualifications:

1. Certification in Radiology, Diagnostic Radiology or Interventional Radiology (IR/DR) by the American Board of Radiology (ABR), the American Osteopathic Board of Radiology, the Royal College of Physicians and Surgeons of Canada, or the Collège des Médecins du Québec, and has performed (with supervision) a sufficient number of EMDA angiographic procedures to demonstrate competency as attested by the supervising physician(s).  
or
2. Completion of a residency program approved by the Accreditation Council for Graduate Medical Education (ACGME), the Royal College of Physicians and Surgeons of Canada (RCPSC), the Collège des Médecins du Québec, or the American Osteopathic Association (AOA) and has performed (with supervision) a sufficient number of EMDA angiographic procedures to demonstrate competency as attested by the supervising physician(s).  
or
3. In the absence of ACGME-recognized residency training as outlined above, in the absence of ACGME-recognized fellowship training in a vascular/interventional radiology fellowship program, or in the absence of other postgraduate training that included comparable instruction and experience in diagnostic angiography, the physician must have at least 2 years of experience and demonstrated competency as primary operator in diagnostic angiography under the direct supervision of an on-site, qualified physician, during which he/she performed a minimum of 100 diagnostic peripheral arteriograms and 50 transluminal angioplasties, 25 of which were EMDA angiographic procedures, as

primary operator with documented success and complication rates that meet the threshold criteria listed below (see section X) [61].

and

4. Substantiation in writing by the director of interventional radiology or the chair of the department of the institution in which the physician will be providing these services that the physician is familiar with all of the following:
  - a. Indications and contraindications for the procedure
  - b. Periprocedural and intraprocedural assessment, monitoring, and management of the patient and complications
  - c. Pharmacology of moderate sedation medications and recognition and treatment of adverse reactions and complications
  - d. Fluoroscopic and radiographic equipment, mechanical injectors, rapid film changers, digital subtraction, and other electronic imaging systems
  - e. Principles of radiation protection, the hazards of radiation, and radiation monitoring requirements as they apply to both patients and personnel
  - f. Pharmacology of contrast agents and recognition and treatment of potential adverse reactions
  - g. Percutaneous needle and catheter introduction techniques
  - h. Technical aspects of performing the procedure, including the use of alternative catheter and guidewire systems, selective angiographic methods, appropriate injection rates and volumes of contrast media, and filming sequences
  - i. Recognition of periprocedural complications and knowledge of treatment options for these complications

#### Maintenance of Competence

Physicians must perform a sufficient number of overall procedures applicable to the spectrum of core privileges to maintain their skills, with acceptable success and complication rates as laid out in this parameter. Continued competence should depend on participation in a quality improvement program that monitors these rates. Consideration should be given to the physician's lifetime practice experience.

#### Continuing Medical Education

The physician's continuing education should be in accordance with the [ACR Practice Parameter for Continuing Medical Education \(CME\)](#) [62].

#### B. Non-Physician Practitioners

Physician assistants and nurse practitioners can be valuable members of the interventional radiology team. These nonphysician practitioners can function as independent members of the team. See the [ACR-SIR-SNIS-SPR Practice Parameter for Interventional Clinical Practice and Management](#) [63].

#### C. Qualified Medical Physicist

A Qualified Medical Physicist is an individual who is competent to practice independently in one or more of the subfields in medical physics. The American College of Radiology (ACR) considers certification, continuing education, and experience in the appropriate subfield(s) to demonstrate that an individual is competent to practice in one or more of the subfields in medical physics, and to be a Qualified Medical Physicist. The ACR strongly recommends that the individual be certified in the appropriate subfield(s) by the American Board of Radiology (ABR), the Canadian College of Physics in Medicine, or by the American Board of Medical Physics (ABMP).

A Qualified Medical Physicist should meet the [ACR Practice Parameter for Continuing Medical Education \(CME\)](#). (ACR Resolution 17, 1996, – Revised in 2012, Resolution 42) [62]

The appropriate subfield of medical physics for this practice parameter is Diagnostic Medical Physics. (Previous medical physics certification categories including Radiological Physics, Diagnostic Radiological Physics, and Diagnostic Imaging Physics are also acceptable.)

#### D. Registered Radiologist Assistant

A registered radiologist assistant is an advanced level radiographer who is certified and registered as a radiologist assistant by the American Registry of Radiologic Technologists (ARRT) after having successfully completed an advanced academic program encompassing an ACR/ASRT (American Society of Radiologic Technologists) radiologist assistant curriculum and a radiologist-directed clinical preceptorship. Under radiologist supervision, the radiologist assistant may perform patient assessment, patient management and selected examinations as delineated in the Joint Policy Statement of the ACR and the ASRT titled “Radiologist Assistant: Roles and Responsibilities” and as allowed by state law. The radiologist assistant transmits to the supervising radiologists those observations that have a bearing on diagnosis. Performance of diagnostic interpretations remains outside the scope of practice of the radiologist assistant. (ACR Resolution 34, adopted in 2006)

#### E. Radiologic Technologist

1. The technologist, together with the physician and nursing personnel, should have the responsibility for patient comfort and safety. The technologist should be able to prepare and position<sup>2</sup> the patient for the procedure and, together with the nurse, monitor the patient during the examination. The technologist should obtain the imaging data in a manner prescribed by the supervising physician. If intravenous contrast material is to be administered, qualifications for the technologist performing intravenous injection should be in compliance with current ACR policy statements<sup>3</sup> and existing operating procedures or manuals at the interventional radiology facility and/or imaging facility. The technologist should also perform the regular quality control testing of the equipment under supervision of the physicist.
2. The technologist should be certified by the American Registry of Radiologic Technologists (ARRT) or have an unrestricted state license, with documented training and experience in the diagnostic angiographic procedure.

#### F. Nursing Services

Nursing services, when deemed appropriate by the performing physician, are an integral part of the team for periprocedural and intraprocedural patient management and education and are recommended in monitoring the patient during the procedure.

### VI. SPECIFICATIONS OF THE EXAMINATION

#### A. Angiographic Equipment and Facilities

The following are considered the minimum equipment requirements for performing EMDA. In planning facilities for EMDA angiography, equipment and facilities more advanced than those outlined below may be desired to produce higher-quality studies with reduced risk and time of study. In general, the facility should include at a

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<sup>2</sup> The American College of Radiology approves of the practice of certified and/or licensed radiologic technologists performing fluoroscopy in a facility or department as a positioning or localizing procedure only, and then only if monitored by a supervising physician who is personally and immediately available\*. There must be a written policy or process for the positioning or localizing procedure that is approved by the medical director of the facility or department/service and that includes written authority or policies and processes for designating radiologic technologists who may perform such procedures. (ACR Resolution 26, 1987 – revised in 2007, Resolution 12m)

\*For the purposes of this parameter, “personally and immediately available” is defined in manner of the “personal supervision” provision of CMS—a physician must be in attendance in the room during the performance of the procedure. Program Memorandum Carriers, DHHS, HCFA, Transmittal B-01-28, April 19, 2001.

<sup>3</sup> See the [ACR–SPR Practice Parameter for the Use of Intravascular Contrast Media](#).

minimum:

1. A high-resolution image intensifier and television chain or flat panel detector with standard angiographic imaging capabilities. Use of last image hold and pulsed fluoroscopy is recommended for dose reduction. The use of cineradiography or small-field mobile image intensifiers is inappropriate for the routine recording of noncoronary angiography because these methods have an unacceptably high patient and operator radiation dose.
2. Adequate angiographic supplies such as catheters, guidewires, needles, and introducer sheaths
3. An angiography suite that is large enough to allow easy transfer of the patient from the bed to the table and to allow room for the procedure table, monitoring equipment, and other hardware such as intravenous pumps, respirators, anesthesia equipment, and oxygen tanks. Ideally, there should be adequate space for the operating team to work unencumbered on either side of the patient and for the circulation of other technical staff in the room without contaminating the sterile conditions.
4. An area for preprocedural preparation and postprocedural observation and monitoring of the patient. At this location, there should be personnel to provide care as outlined in the Patient Care section below, and there should be immediate access to emergency resuscitation equipment.

#### B. Physiologic Monitoring and Resuscitation Equipment

1. Sufficient equipment should be present in the angiography suite to allow for monitoring the patient's heart rate, cardiac rhythm, and blood pressure. For facilities using moderate sedation, a pulse oximeter or an end-tidal carbon dioxide monitor should be available (see the [ACR–SIR Practice Parameter for Sedation/Analgesia](#) [64]).
2. There should be ready access to emergency resuscitation equipment and drugs, including the following: oxygen supply and appropriate tubing and delivery systems, suction equipment, tubes for endotracheal intubation, laryngoscope, ventilation bag-mask-valve apparatus, and central venous line sets. Drugs for treating cardiopulmonary arrest, contrast reaction, vasovagal reactions, narcotic or benzodiazepine overdose, bradycardia, and ventricular arrhythmias should also be readily available. Resuscitation equipment should be monitored on a routine basis in compliance with institutional policies.

#### C. Support Personnel

1. Radiologic technologists properly trained in the use of the arteriographic equipment should assist in performing and imaging the procedure. They should demonstrate appropriate knowledge of patient positioning, arteriographic image recording, angiographic contrast injectors, angiographic supplies, and physiologic monitoring equipment. Certification as a vascular and interventional radiologic technologist is one measure of appropriate training. The technologists should be trained in basic cardiopulmonary resuscitation and in the function of the resuscitation equipment.
2. If the patient does not receive moderate sedation, one of the staff assisting in the procedure should be assigned to periodically assess the patient's status. If the patient is to undergo moderate sedation, a nurse or other appropriately trained individual should monitor the patient as his/her primary responsibility. This person should maintain a record of the patient's vital signs, time and dose of medications given, and other pertinent information. Nursing personnel should be qualified to administer moderate sedation (see the [ACR–SIR Practice Parameter for Sedation/Analgesia](#) [64]).

#### D. Surgical Support

Although complications of EMDA only rarely require urgent surgery, these procedures should be performed in an environment where operative repair can be instituted promptly. Ideally, this would be an acute-care hospital with adequate surgical, anesthesia, and ancillary support. When these procedures are performed in a freestanding

outpatient center, detailed protocols for the rapid transport or admission of patients to an acute-care hospital should be formalized in writing.

## E. Patient Care

### 1. Preprocedure care

The physician performing the procedure must have knowledge of the following:

- a. Clinically significant history, including indications for the procedure
- b. Clinically significant physical examination findings, including an awareness of clinical or medical conditions that may necessitate specific care
- c. Possible alternative methods, such as surgical or medical treatments, to obtain the desired therapeutic result
- d. Exposure factors, including kVp, mA, magnification factor, and dose rate. Additional parameters such as collimation, field of view, fluoroscopic frame rates, and last image hold should be considered.

### 2. Procedural care

- a. Adherence to the Joint Commission's Universal Protocol for Preventing Wrong Site, Wrong Procedure, Wrong Person Surgery™ is required for procedures in nonoperating room settings, including bedside procedures.

The organization should have processes and systems in place for reconciling differences in staff responses during the "time out."

- b. All patients should have cardiac monitoring continuously during the procedure, with intermittent blood pressure monitoring. A record of vital signs should be maintained.
- c. If the patient is to receive moderate sedation, pulse oximetry should be used. A registered nurse or other appropriately trained personnel should be present, and his/her primary responsibility should be to monitor the patient. A record should be kept of medication doses and times of administration.
- d. A physician should be available during the immediate postprocedure period.

### 3. Postprocedure care

- a. A written summary of the major findings of the study and any immediate complications should be documented and included in the patient's medical records. This note may be brief if a formal report will be available within a few hours. However, if the typed report is not likely to be on the chart the same day, a more detailed summary of the study should be written in the chart at the conclusion of the procedure. In all cases, pertinent findings should be communicated to the referring physician in a timely manner.
- b. All patients should be observed during the postprocedure period. The length of this period will depend on the type and extent of the procedures and the patient's medical condition.
- c. Qualified, trained personnel should periodically monitor the patient's vascular access during the initial postprocedure period.
- d. The operating physician or a qualified designee should evaluate the patient during the postoperative period. If moderate sedation was administered prior to and during the procedure, recovery from the sedation must be documented. The physician or designee should be available for continuing care during hospitalization and after discharge. The designee may be another physician or a nurse. See the [ACR–SIR Practice Parameter for Sedation/ Analgesia](#) [64].

Informed consent must be in compliance with all state laws and the [ACR–SIR Practice Parameter on Informed Consent for Image-Guided Procedures](#) [65].

## F. Selection Criteria for Short-Term Observation

The duration of postprocedure observation is variable and depends on the type and extent of the procedure and the condition of the patient.

## **VII. DOCUMENTATION**

Documentation and reporting should be in accordance with the [ACR–SIR–SPR Practice Parameter for the Reporting and Archiving of Interventional Radiology Procedures](#) [66].

## **VIII. RADIATION SAFETY IN IMAGING**

Radiologists, medical physicists, registered radiologist assistants, radiologic technologists, and all supervising physicians have a responsibility for safety in the workplace by keeping radiation exposure to staff, and to society as a whole, “as low as reasonably achievable” (ALARA) and to assure that radiation doses to individual patients are appropriate, taking into account the possible risk from radiation exposure and the diagnostic image quality necessary to achieve the clinical objective. All personnel that work with ionizing radiation must understand the key principles of occupational and public radiation protection (justification, optimization of protection and application of dose limits) and the principles of proper management of radiation dose to patients (justification, optimization and the use of dose reference levels) [http://www-pub.iaea.org/MTCD/Publications/PDF/Pub1578\\_web-57265295.pdf](http://www-pub.iaea.org/MTCD/Publications/PDF/Pub1578_web-57265295.pdf).

Nationally developed guidelines, such as the ACR’s Appropriateness Criteria®, should be used to help choose the most appropriate imaging procedures to prevent unwarranted radiation exposure.

Facilities should have and adhere to policies and procedures that require varying ionizing radiation examination protocols (plain radiography, fluoroscopy, interventional radiology, CT) to take into account patient body habitus (such as patient dimensions, weight, or body mass index) to optimize the relationship between minimal radiation dose and adequate image quality. Automated dose reduction technologies available on imaging equipment should be used whenever appropriate. If such technology is not available, appropriate manual techniques should be used.

Additional information regarding patient radiation safety in imaging is available at the Image Gently® for children ([www.imagegently.org](http://www.imagegently.org)) and Image Wisely® for adults ([www.imagewisely.org](http://www.imagewisely.org)) websites. These advocacy and awareness campaigns provide free educational materials for all stakeholders involved in imaging (patients, technologists, referring providers, medical physicists, and radiologists).

Radiation exposures or other dose indices should be measured and patient radiation dose estimated for representative examinations and types of patients by a Qualified Medical Physicist in accordance with the applicable ACR technical standards. Regular auditing of patient dose indices should be performed by comparing the facility’s dose information with national benchmarks, such as the ACR Dose Index Registry, the NCRP Report No. 172, Reference Levels and Achievable Doses in Medical and Dental Imaging: Recommendations for the United States or the Conference of Radiation Control Program Director’s National Evaluation of X-ray Trends. (ACR Resolution 17 adopted in 2006 – revised in 2009, 2013, Resolution 52).

## **IX. 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 *Position Statement on QC & Improvement, Safety, Infection Control, and Patient Education* on the ACR website (<http://www.acr.org/guidelines>).

## **X. QUALITY IMPROVEMENT**

Although practicing physicians should strive to achieve perfect outcomes (ie, 100% success, 0% complications), in practice all physicians will fall short of this ideal to a variable extent. Thus, indicator thresholds may be used to assess the efficacy of ongoing quality improvement programs. For the purpose of these practice parameters, a threshold is a specific level of an indicator that should prompt a review. Procedural thresholds or overall

thresholds reference a group of indicators for a procedure (eg, major complications of percutaneous management of thrombosed or dysfunctional dialysis access).

Individual complications may also be associated with complication-specific thresholds. When measures such as indications or success rates fall below a minimum threshold or when complication rates exceed a maximum threshold, a review should be performed to determine causes and to implement changes, if necessary.

Thresholds may vary from those listed here; for example, patient referral patterns and selection factors may dictate a different threshold value for a particular indicator at a particular institution. Thus, setting universal thresholds is very difficult, and each department is urged to alter the thresholds as needed to higher or lower values to meet its own quality improvement program needs.

#### A. Success Rate and Threshold

An important indicator of success is the ability to perform EMDA procedures in an expeditious fashion. This allows rapid resumption of hemodialysis treatment and decreases the use of temporary hemodialysis catheters. This work group endorses the NKF/DOQI position that “no more than one and preferably no femoral vein catheterizations should be required” [1].

The success rates and patency data are presented below. It is recognized that extenuating circumstances may cause lower patency rates not related to stenosis of the graft or fistula. These circumstances include, but are not limited to:

- The need for compression of the graft to achieve hemostasis
- Dehydration of the patient, decreasing the effective circulating volume
- Unusual extrinsic pressure on the graft or fistula, such as from tight-fitting clothing or from sleeping with the graft partially kinked

1. Success in the treatment of prosthetic graft stenoses by balloon angioplasty in a screened group of patients with a significant stenosis

The figures below reflect patency rates reported in the literature with life-table analysis [17-19,21,22,67]. The results reported below are for stenoses that are generally solitary and less than 6 cm in length. Longer stenoses and stenoses that have undergone multiple dilatations will have poorer patency than focal stenoses dilated for the first time.

If angioplasty is required more than twice within 3 months, the patient should be referred for surgical revision if such an option is available and if the patient is a good surgical candidate. Stent or stent graft placement is often used in the following situations: 1) inadequate alternative access sites, 2) the patient is not a good surgical candidate, and 3) angioplasty-induced venous rupture.

**TABLE 1.**

<b><u>Prosthetic Grafts</u></b>	<b><u>Reported Rates</u></b>	<b><u>Suggested Threshold</u></b>
Clinical success	72% to 98%	85%
Cumulative patency		
6 months primary	20% to 63%	25%*
12 months primary	23% to 44%	**
12 months secondary***	61% to 82%	**

\* NKF/DOQI guidelines recommend a goal of 50% primary patency rate at 6 months [1,22,55]. However, 2 recent multicenter, prospective, randomized studies suggest that grafts followed with close monitoring after angioplasty have significantly lower 6-month primary patencies.

\*\* Inadequate data exist at the present time to propose threshold values.

\*\*\* Includes thrombolysis

2. Success in the treatment of autogenous fistula stenoses by balloon angioplasty in a screened group of patients with a significant stenosis

The figures below reflect patency rates reported in the literature with life-table analysis [21,41,68-73]. The cumulative patency results are generally better than reported for grafts.

As for grafts, if angioplasty is required more than twice within 3 months, the patient should be referred for surgical revision if such an option is available and if the patient is a good surgical candidate. Stent or stent placement is often used in the following situations: 1) inadequate alternative access sites, 2) the patient is not a good surgical candidate, and 3) angioplasty-induced venous rupture.

**TABLE 2.**

<b><u>Autogenous Fistulae</u></b>	<b><u>Reported Rates</u></b>	<b><u>Suggested Threshold</u></b>
Clinical success	85% to 99%	85%
Cumulative patency		
6 months primary	50% to 75%	50%*
12 months primary	26% to 62%	**
12 months secondary [1]	82% to 86%	**

\* NKF/DOQI guidelines recommend a goal of 40% primary patency rate at 3 months [1]. However, 3 recent studies [74-76] suggest that autogenous fistulae have lower initial clinical success rates and primary patencies, possibly related to a combination of a learning curve and close monitoring.

\*\* Inadequate data exist at the present time to propose threshold values.

3. Successful treatment of synthetic graft stenoses associated with thrombosis

Successful treatment of synthetic graft stenosis in conjunction with thrombosis yields poorer patency than treatment of nonthrombosed stenoses and is more difficult to achieve than successful treatment of nonthrombosed stenoses. If the access thromboses >2 times within a 3-month interval and a recurrent correctable lesion is identified, the patient should be referred for surgical revision if such an option is available and there are no contraindications. The work group believes that there are instances when factors other than correctable lesions cause thrombosis, such as hypotension or extrinsic compression. Primary patency data for thrombolysis and mechanical thrombectomy are similar, and the results are reported together below.

**TABLE 3.**

<b><u>Synthetic Graft</u></b>	<b><u>Reported Rates</u></b>	<b><u>Suggested Threshold*</u></b>
Clinical success	75% to 94%	85%
Cumulative patency		
3 months primary	37% to 58%	40% [1]
6 months primary	18% to 39%	20%
6 months secondary	62% to 80%	65%
12 months secondary	57% to 69%	

\* Inadequate data exist at the present time to propose threshold values.

4. Successful treatment of autogenous fistula stenoses associated with thrombosis

The success rates and patency data for endovascular thrombectomy of fistulae are presented below [68,69,74-79]. The data are limited relative to those for angioplasty of stenoses in screened populations.

**TABLE 4.**

<b><u>Autogenous Fistulae</u></b>	<b><u>Reported Rates</u></b>	<b><u>Suggested Threshold</u></b>
Clinical success	73% to 94%	75%
Cumulative patency		
3 months primary	30% to 89%	30%*
6 months primary	20% to 81%	**
12 months primary	18% to 84%	**
12 months secondary [1]	44% to 80%	**

\* NKF/DOQI guidelines recommend a goal of 40% primary patency rate at 3 months [1]. However, 3 recent studies

[75,77,78] suggest that autogenous fistulae have lower initial clinical success rates and primary patencies, possibly related to a combination of a learning curve and close monitoring.

\*\* Inadequate data exist at the present time to propose threshold values.

5. Successful treatment of steal syndrome

Success rates and patency data for the variety of treatments reported for steal are too limited to make threshold recommendations.

B. Complication Rates and Threshold [6,12-14]

Complications can be stratified on the basis of outcome. *Major* complications are defined as requiring any 1 of the following: 1) admission to a hospital for therapy (for outpatient procedures), 2) an unplanned increase in level of care, 3) permanent adverse sequelae, or 4) death. The complication rates and thresholds below refer to *major* complications. *Minor* complications result in no long-term sequelae, although they may require nominal therapy or a short hospital stay for observation (generally overnight) (see Appendix B).

TABLE 5.

<u>Complication</u>	<u>Reported Rates</u>	<u>Suggested Threshold</u>
Symptomatic embolization, arterial	1% to 9%	2%
Hematoma/bleed, remote site	2% to 3%	3%*
Vascular perforation or rupture	2% to 4%	0.5%**
Death***	<1%	0.5%****
Symptomatic pulmonary embolism	<1%	0.5%

\* Thrombolysis with prolonged infusion

\*\* Reported rates include minor perforations. Threshold applies to perforations or rupture requiring blood transfusion or emergent surgery or resulting in limb-threatening ischemia.

\*\*\* Procedure-related 30-day mortality data are not available but should be reported [32].

\*\*\*\* All deaths should prompt an appropriate case review.

Published rates for individual types of complications are highly dependent on patient selection and are based on series comprising several hundred patients, which is a volume larger than most individual practitioners are likely to treat. It is also recognized that a single complication can cause a rate to cross above a complication-specific threshold when the complication occurs in a small volume of patients (eg, early in a quality improvement program). In this situation, the overall procedure threshold is more appropriate for use in a quality improvement program.

Major and minor complications occur in up to 10% of patients. Complication rates can be expected to be lower in managing the nonthrombosed dialysis access.

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## REFERENCES

1. Clinical practice guidelines for vascular access. *Am J Kidney Dis.* 2006;48 Suppl 1:S176-247.
2. 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. *Journal of vascular surgery.* 2008;48(5 Suppl):2S-25S.
3. Berger MF, Aruny JE, Skibo LK. Recurrent thrombosis of polytetrafluoroethylene dialysis fistulas after recent surgical thrombectomy: salvage by means of thrombolysis and angioplasty. *J Vasc Interv Radiol.* 1994;5(5):725-730.
4. Cohen MA, Kumpe DA, Durham JD, Zwerdinger SC. Improved treatment of thrombosed hemodialysis access sites with thrombolysis and angioplasty. *Kidney Int.* 1994;46(5):1375-1380.
5. Davis GB, Dowd CF, Bookstein JJ, Maroney TP, Lang EV, Halasz N. Thrombosed dialysis grafts: efficacy of intrathrombic deposition of concentrated urokinase, clot maceration, and angioplasty. *AJR Am J Roentgenol.* 1987;149(1):177-181.
6. Roberts AC, Valji K, Bookstein JJ, Hye RJ. Pulse-spray pharmacomechanical thrombolysis for treatment of thrombosed dialysis access grafts. *Am J Surg.* 1993;166(2):221-225; discussion 225-226.
7. Trerotola SO, Vesely TM, Lund GB, Soulen MC, Ehrman KO, Cardella JF. Treatment of thrombosed hemodialysis access grafts: Arrow-Trerotola percutaneous thrombolytic device versus pulse-spray thrombolysis. Arrow-Trerotola Percutaneous Thrombolytic Device Clinical Trial. *Radiology.* 1998;206(2):403-414.
8. Valji K, Bookstein JJ, Roberts AC, Oglevie SB, Pittman C, O'Neill MP. Pulse-spray pharmacomechanical thrombolysis of thrombosed hemodialysis access grafts: long-term experience and comparison of original and current techniques. *AJR Am J Roentgenol.* 1995;164(6):1495-1500; discussion 1501-1493.
9. Sofocleous CT, Hinrichs CR, Weiss SH, et al. Alteplase for hemodialysis access graft thrombolysis. *J Vasc Interv Radiol.* 2002;13(8):775-784.
10. Turmel-Rodrigues L, Sapoval M, Pengloan J, et al. Manual thromboaspiration and dilation of thrombosed dialysis access: mid-term results of a simple concept. *J Vasc Interv Radiol.* 1997;8(5):813-824.
11. Soulen MC, Zaetta JM, Amygdalos MA, Baum RA, Haskal ZJ, Shlansky-Goldberg RD. Mechanical declotting of thrombosed dialysis grafts: experience in 86 cases. *J Vasc Interv Radiol.* 1997;8(4):563-567.
12. Uflacker R, Rajagopalan PR, Vujic I, Stutley JE. Treatment of thrombosed dialysis access grafts: randomized trial of surgical thrombectomy versus mechanical thrombectomy with the Amplatz device. *J Vasc Interv Radiol.* 1996;7(2):185-192.
13. Middlebrook MR, Amygdalos MA, Soulen MC, et al. Thrombosed hemodialysis grafts: percutaneous mechanical balloon declotting versus thrombolysis. *Radiology.* 1995;196(1):73-77.
14. Sharafuddin MJ, Kadir S, Joshi SJ, Parr D. Percutaneous balloon-assisted aspiration thrombectomy of clotted hemodialysis access grafts. *J Vasc Interv Radiol.* 1996;7(2):177-183.
15. Gilula LA, Staple TW, Anderson CB, Anderson LS. Venous angiography of hemodialysis fistulas. Experience with 52 studies. *Radiology.* 1975;115(3):555-562.
16. Picus D, van Breda A, Katzen BT, Steinberg DL. Use of digital subtraction angiography for evaluation of vascular access for hemodialysis. *Cardiovasc Intervent Radiol.* 1987;10(4):210-214.
17. Beathard GA. Percutaneous transvenous angioplasty in the treatment of vascular access stenosis. *Kidney Int.* 1992;42(6):1390-1397.
18. Kanterman RY, Vesely TM, Pilgram TK, Guy BW, Windus DW, Picus D. Dialysis access grafts: anatomic location of venous stenosis and results of angioplasty. *Radiology.* 1995;195(1):135-139.
19. Safa AA, Valji K, Roberts AC, Ziegler TW, Hye RJ, Oglevie SB. Detection and treatment of dysfunctional hemodialysis access grafts: effect of a surveillance program on graft patency and the incidence of thrombosis. *Radiology.* 1996;199(3):653-657.
20. Schwartz CI, McBrayer CV, Sloan JH, Meneses P, Ennis WJ. Thrombosed dialysis grafts: comparison of treatment with transluminal angioplasty and surgical revision. *Radiology.* 1995;194(2):337-341.
21. 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(1):273-278.

22. Vesely TM, Siegel JB. Use of the peripheral cutting balloon to treat hemodialysis-related stenoses. *J Vasc Interv Radiol.* 2005;16(12):1593-1603.
23. Zemel G, Katzen BT, Dake MD, Benenati JF, Lempert TE, Moskowitz L. Directional atherectomy in the treatment of stenotic dialysis access fistulas. *J Vasc Interv Radiol.* 1990;1(1):35-38.
24. Beathard GA. Gianturco self-expanding stent in the treatment of stenosis in dialysis access grafts. *Kidney Int.* 1993;43(4):872-877.
25. Gray RJ, Horton KM, Dolmatch BL, et al. Use of Wallstents for hemodialysis access-related venous stenoses and occlusions untreatable with balloon angioplasty. *Radiology.* 1995;195(2):479-484.
26. Hoffer EK, Sultan S, Herskowitz MM, Daniels ID, Sclafani SJ. Prospective randomized trial of a metallic intravascular stent in hemodialysis graft maintenance. *J Vasc Interv Radiol.* 1997;8(6):965-973.
27. Quinn SF, Schuman ES, Hall L, et al. Venous stenoses in patients who undergo hemodialysis: treatment with self-expandable endovascular stents. *Radiology.* 1992;183(2):499-504.
28. Shoenfeld R, Hermans H, Novick A, et al. Stenting of proximal venous obstructions to maintain hemodialysis access. *Journal of vascular surgery.* 1994;19(3):532-538; discussion 538-539.
29. Turmel-Rodrigues LA, Blanchard D, Pengloan J, et al. Wallstents and Craggstents in hemodialysis grafts and fistulas: results for selective indications. *J Vasc Interv Radiol.* 1997;8(6):975-982.
30. Vorwerk D, Guenther RW, Mann H, et al. Venous stenosis and occlusion in hemodialysis shunts: follow-up results of stent placement in 65 patients. *Radiology.* 1995;195(1):140-146.
31. Aruny JE, Lewis CA, Cardella JF, et al. Quality improvement guidelines for percutaneous management of the thrombosed or dysfunctional dialysis access. Standards of Practice Committee of the Society of Cardiovascular & Interventional Radiology. *J Vasc Interv Radiol.* 1999;10(4):491-498.
32. Gray RJ, Sacks D, Martin LG, Trerotola SO. Reporting standards for percutaneous interventions in dialysis access. *J Vasc Interv Radiol.* 2003;14(9 Pt 2):S433-442.
33. Sidawy AN, Gray R, Besarab A, et al. Recommended standards for reports dealing with arteriovenous hemodialysis accesses. *Journal of vascular surgery.* 2002;35(3):603-610.
34. Ahya SN, Windus DW, Vesely TM. Flow in hemodialysis grafts after angioplasty: Do radiologic criteria predict success? *Kidney Int.* 2001;59(5):1974-1978.
35. Amin MZ, Vesely TM, Pilgram T. Correlation of intragraft blood flow with characteristics of stenoses found during diagnostic fistulography. *J Vasc Interv Radiol.* 2004;15(6):589-593.
36. White JJ, Ram SJ, Jones SA, Schwab SJ, Paulson WD. Influence of luminal diameters on flow surveillance of hemodialysis grafts: insights from a mathematical model. *Clin J Am Soc Nephrol.* 2006;1(5):972-978.
37. Trerotola SO, Ponce P, Stavropoulos SW, et al. Physical examination versus normalized pressure ratio for predicting outcomes of hemodialysis access interventions. *J Vasc Interv Radiol.* 2003;14(11):1387-1394.
38. Vesely TM, Gherardini D, Gleed RD, Kislukhin V, Krivitski NM. Use of a catheter-based system to measure blood flow in hemodialysis grafts during angioplasty procedures. *J Vasc Interv Radiol.* 2002;13(4):371-378.
39. Sullivan KL, Besarab A. Hemodynamic screening and early percutaneous intervention reduce hemodialysis access thrombosis and increase graft longevity. *J Vasc Interv Radiol.* 1997;8(2):163-170.
40. Spergel LM, Holland JE, Fadem SZ, McAllister CJ, Peacock EJ. Static intra-access pressure ratio does not correlate with access blood flow. *Kidney Int.* 2004;66(4):1512-1516.
41. Asif A, Leon C, Merrill D, et al. Arterial steal syndrome: a modest proposal for an old paradigm. *Am J Kidney Dis.* 2006;48(1):88-97.
42. Raynaud A, Novelli L, Rovani X, et al. Radiocephalic fistula complicated by distal ischemia: treatment by ulnar artery dilatation. *Cardiovasc Intervent Radiol.* 2010;33(1):223-225.
43. Trespalacios FC, Taylor AJ, Agodoa LY, Bakris GL, Abbott KC. Heart failure as a cause for hospitalization in chronic dialysis patients. *Am J Kidney Dis.* 2003;41(6):1267-1277.
44. Bosanac PR, Bilder B, Grunberg RW, Banach SF, Kintzel JE, Stephens HW. Post-permanent access neuropathy. *Trans Am Soc Artif Intern Organs.* 1977;23:162-167.
45. Beathard GA, Settle SM, Shields MW. Salvage of the nonfunctioning arteriovenous fistula. *Am J Kidney Dis.* 1999;33(5):910-916.
46. Falk A. Maintenance and salvage of arteriovenous fistulas. *J Vasc Interv Radiol.* 2006;17(5):807-813.
47. Miller GA, Goel N, Khariton A, et al. Aggressive approach to salvage non-maturing arteriovenous fistulae: a retrospective study with follow-up. *J Vasc Access.* 2009;10(3):183-191.

48. Nassar GM, Nguyen B, Rhee E, Achkar K. Endovascular treatment of the "failing to mature" arteriovenous fistula. *Clin J Am Soc Nephrol*. 2006;1(2):275-280.
49. Raynaud A, Novelli L, Bourquelot P, Stolba J, Beyssen B, Franco G. Low-flow maturation failure of distal accesses: Treatment by angioplasty of forearm arteries. *Journal of vascular surgery*. 2009;49(4):995-999.
50. Turmel-Rodrigues L, Mouton A, Birmele B, et al. Salvage of immature forearm fistulas for haemodialysis by interventional radiology. *Nephrol Dial Transplant*. 2001;16(12):2365-2371.
51. Beathard GA, Arnold P, Jackson J, Litchfield T. Aggressive treatment of early fistula failure. *Kidney Int*. 2003;64(4):1487-1494.
52. Vesely TM, Hovsepian DM, Pilgram TK, Coyne DW, Shenoy S. Upper extremity central venous obstruction in hemodialysis patients: treatment with Wallstents. *Radiology*. 1997;204(2):343-348.
53. Vogel PM, Parise C. SMART stent for salvage of hemodialysis access grafts. *J Vasc Interv Radiol*. 2004;15(10):1051-1060.
54. Quinn SF, Schuman ES, Demlow TA, et al. Percutaneous transluminal angioplasty versus endovascular stent placement in the treatment of venous stenoses in patients undergoing hemodialysis: intermediate results. *J Vasc Interv Radiol*. 1995;6(6):851-855.
55. Haskal ZJ, Trerotola S, Dolmatch B, et al. Stent graft versus balloon angioplasty for failing dialysis-access grafts. *N Engl J Med*. 2010;362(6):494-503.
56. Vesely T, DaVanzo W, Behrend T, Dwyer A, Aruny J. Balloon angioplasty versus Viabahn stent graft for treatment of failing or thrombosed prosthetic hemodialysis grafts. *Journal of vascular surgery*. 2016;64(5):1400-1410 e1401.
57. West JC, Bertsch DJ, Peterson SL, et al. Arterial insufficiency in hemodialysis access procedures: correction by "banding" technique. *Transplant Proc*. 1991;23(2):1838-1840.
58. Schanzer H, Skladany M, Haimov M. Treatment of angioaccess-induced ischemia by revascularization. *Journal of vascular surgery*. 1992;16(6):861-864; discussion 864-866.
59. Chemla E, Raynaud A, Carreres T, et al. Preoperative assessment of the efficacy of distal radial artery ligation in treatment of steal syndrome complicating access for hemodialysis. *Ann Vasc Surg*. 1999;13(6):618-621.
60. Miller GA, Khariton K, Kardos SV, Koh E, Goel N, Khariton A. Flow interruption of the distal radial artery: treatment for finger ischemia in a matured radiocephalic AVF. *J Vasc Access*. 2008;9(1):58-63.
61. Levin DC, Becker GJ, Dorros G, et al. Training standards for physicians performing peripheral angioplasty and other percutaneous peripheral vascular interventions. A statement for health professionals from the Special Writing Group of the Councils on Cardiovascular Radiology, Cardio-Thoracic and Vascular Surgery, and Clinical Cardiology, the American Heart Association. *Circulation*. 1992;86(4):1348-1350.
62. American College of Radiology. ACR practice parameter for continuing medical education (CME). 2011; Available at: <https://www.acr.org/-/media/ACR/Files/Practice-Parameters/CME.pdf>. Accessed June 18, 2015.
63. American College of Radiology. ACR-SIR-SNIS-SPR practice parameter for interventional clinical practice and management. 2014; Available at: <https://www.acr.org/-/media/ACR/Files/Practice-Parameters/IRClin-Prac-Mgmt.pdf>. Accessed June 18, 2015.
64. American College of Radiology. ACR-SIR practice parameter for sedation/analgesia. 2015; Available at: <https://www.acr.org/-/media/ACR/Files/Practice-Parameters/Sed-Analgesia.pdf>. Accessed June 18, 2015.
65. American College of Radiology. ACR-SIR practice parameter on informed consent for image-guided procedures. 2011; Available at: <https://www.acr.org/-/media/ACR/Files/Practice-Parameters/InformedConsent-ImagGuided.pdf>. Accessed June 18, 2015.
66. American College of Radiology. ACR-SIR-SPR practice parameter for the reporting and archiving of interventional radiology procedures. 2014; Available at: <https://www.acr.org/-/media/ACR/Files/Practice-Parameters/Reporting-Archiv.pdf>. Accessed June 19, 2015.
67. Lilly RZ, Carlton D, Barker J, et al. Predictors of arteriovenous graft patency after radiologic intervention in hemodialysis patients. *Am J Kidney Dis*. 2001;37(5):945-953.
68. Clark TW, Hirsch DA, Jindal KJ, Veugelers PJ, LeBlanc J. Outcome and prognostic factors of restenosis after percutaneous treatment of native hemodialysis fistulas. *J Vasc Interv Radiol*. 2002;13(1):51-59.
69. Maeda K, Furukawa A, Yamasaki M, Murata K. Percutaneous transluminal angioplasty for Brescia-Cimino hemodialysis fistula dysfunction: technical success rate, patency rate and factors that influence the results. *Eur J Radiol*. 2005;54(3):426-430.

70. Manninen HI, Kaukanen ET, Ikaheimo R, et al. Brachial arterial access: endovascular treatment of failing Brescia-Cimino hemodialysis fistulas--initial success and long-term results. *Radiology*. 2001;218(3):711-718.
71. Maya ID, Oser R, Saddekni S, Barker J, Allon M. Vascular access stenosis: comparison of arteriovenous grafts and fistulas. *Am J Kidney Dis*. 2004;44(5):859-865.
72. 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(2):508-515.
73. van der Linden J, Smits JH, Assink JH, et al. Short- and long-term functional effects of percutaneous transluminal angioplasty in hemodialysis vascular access. *J Am Soc Nephrol*. 2002;13(3):715-720.
74. Jain G, Maya ID, Allon M. Outcomes of percutaneous mechanical thrombectomy of arteriovenous fistulas in hemodialysis patients. *Semin Dial*. 2008;21(6):581-583.
75. Rajan DK, Clark TW, Simons ME, Kachura JR, Sniderman K. Procedural success and patency after percutaneous treatment of thrombosed autogenous arteriovenous dialysis fistulas. *J Vasc Interv Radiol*. 2002;13(12):1211-1218.
76. Shatsky JB, Berns JS, Clark TW, et al. Single-center experience with the Arrow-Trerotola Percutaneous Thrombectomy Device in the management of thrombosed native dialysis fistulas. *J Vasc Interv Radiol*. 2005;16(12):1605-1611.
77. Haage P, Vorwerk D, Wildberger JE, Piroth W, Schurmann K, Gunther RW. Percutaneous treatment of thrombosed primary arteriovenous hemodialysis access fistulae. *Kidney Int*. 2000;57(3):1169-1175.
78. Liang HL, Pan HB, Chung HM, et al. Restoration of thrombosed Brescia-Cimino dialysis fistulas by using percutaneous transluminal angioplasty. *Radiology*. 2002;223(2):339-344.
79. Turmel-Rodrigues L, Pengloan J, Baudin S, et al. Treatment of stenosis and thrombosis in haemodialysis fistulas and grafts by interventional radiology. *Nephrol Dial Transplant*. 2000;15(12):2029-2036.

## APPENDIX A

### STATIC PRESSURE MEASUREMENTS IN SYNTHETIC DIALYSIS GRAFTS

Intra-access pressure measurements are made with a straight end-hole catheter. The catheter tip can be positioned in the native artery or vein as well as at any position within the graft. Because pressure in the graft reflects the patient's systemic blood pressure, the systolic graft pressure is divided by the systemic systolic pressure measured from a blood pressure cuff on the contralateral arm, yielding a normalized ratio [1]. A normalized systolic pressure ratio of 0.4 has both a high sensitivity (92%) and specificity (86%) in identifying at least 50% stenosis.

The positive predictive value is 92%, and the negative predictive value is 84%.

The goal of intervention is to achieve a pressure ratio of <0.5 in the arterial limb and <0.33 in the venous limb of the graft.

#### REFERENCE (Appendix A)

1. Sullivan LK, Bessarab A. Hemodynamic screening and early percutaneous intervention reduce hemodialysis access thrombosis and increase graft longevity. *J Vasc Interv Radiol* 1997;8:163-170.

## APPENDIX B

### Society of Interventional Radiology Standards of Practice Committee Classification of Complications by Outcome

#### Minor Complications

- A. No therapy, no consequence
- B. Nominal therapy, no consequence; includes overnight admission for observation only

#### Major Complications

- A. Require therapy, minor hospitalization (<48 hours)
- B. Require major therapy, unplanned increase in level of care, prolonged hospitalization (>48 hours)
- C. Permanent adverse sequelae
- D. Death

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\*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 parameters or technical standard was amended, revised, or approved by the ACR Council.

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