ACR–SIR PRACTICE PARAMETER FOR ENDOVASCULAR MANAGEMENT OF THE THROMBOSED OR DYSFUNCTIONAL 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 considering 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 variables such as the condition of the patient, limitations of available resources, or advances in knowledge or technology after publication of this document. However, a practitioner who employs an approach substantially different from the guidance in this document may consider documenting in the patient record information sufficient to explain the approach taken.

The practice of medicine involves the science, and 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 purpose of this document is to assist practitioners in achieving this objective.

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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

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 often the first-line treatment option for a variety of indications over surgical thrombectomy and revision [1,2]. Indications for endovascular management include access thrombosis, inadequate blood flow through the access to allow for

optimal hemodialysis, regional swelling, clinical symptoms or noninvasive assessments that indicate the access is at increased risk of thrombosis, and access complications such as pseudoaneurysm or steal syndrome [3]. Successful thrombectomy procedures can be performed using pharmacologic thrombolysis [4-10], aspiration thrombectomy [11], mechanical thrombectomy [9,11-13], balloon thrombectomy [14,15], or combinations of these methods. A complete endovascular procedure includes diagnostic imaging of the graft or fistula with evaluation of the arterial inflow as well as the draining veins to the level of the right atrium. By using both diagnostic imaging and physical examination, stenoses that may be the anatomic cause of access failure or reduced function are identified. For hemodynamically significant stenoses, improvement in flow can be achieved with balloon angioplasty [4,5,10,14,16-22] and endovascular stents [20,23-29] or stent grafts [30-35]. These procedures frequently are the initial treatment for a thrombosed or dysfunctional hemodialysis access, with transluminal angioplasty being the preferred initial treatment of central vein stenosis to resolve upper extremity edema and, less commonly, to relieve access dysfunction [1].

Compared with surgical procedures, endovascular dialysis access procedures are less invasive, are less time consuming, and result in faster recovery with less postprocedure discomfort. 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 hemodialysis treatment on the same day.

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

Appropriate endovascular management of dysfunctional hemodialysis vascular access includes:

1. Review of the procedural indication
2. Clinical assessment of the patient and physical evaluation of the vascular access
3. Thorough diagnostic imaging evaluation of the vascular access circuit
4. Identification and treatment of hemodynamically significant stenoses that match the clinical indicators
5. Assessment of the technical and clinical success of the procedure
6. Determination of the follow-up plan

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. INDICATIONS AND CONTRAINDICATIONS

A. Indications

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

a. A functionally significant hemodialysis access stenosis causing a > 50% reduction in luminal diameter [36-38].
b. Access thrombosis: Thrombosis is associated with underlying venous stenosis in >85% of cases [10,37,38].
c. Central vein stenosis >50% lumen reduction, when clinical parameters such as regional swelling, or, rarely, hemodynamic compromise of the access are present. Endovascular intervention with transluminal angioplasty is the preferred treatment of central vein stenosis [1,37,38].
d. Autogenous fistulae that have failed to mature as expected 4 to 6 weeks after creation. Treatments include:
    i. Most commonly, balloon angioplasty of stenoses within the fistula or inflow artery to increase blood flow [37-44].
    ii. In specific circumstances, occlusion of communicating veins that arise from the fistula venous inflow, peripheral to the cannulation segment, to increase blood flow within the fistula and hasten maturation [37-40,42,45].

II. INDICATIONS AND CONTRAINDICATIONS

A. Indications

2. Indications for Endoluminal Stent Placement

Several nonrandomized studies have demonstrated acceptable patency for bare metal stents following unsuccessful balloon angioplasty, especially for central vein lesions [23,24,37,46,47]. However, several prospective, randomized trials have failed to show a benefit of bare stents over percutaneous transluminal angioplasty alone in the treatment of dialysis access stenoses [25,37,48]. Stent-grafts may provide longer patency than bare stents for dialysis access stenoses. Prospective, randomized, multicenter studies show better primary target lesion and circuit patency after stent-graft placement at the venous anastomosis of grafts than after angioplasty alone [31,32,35]. For treatment of in-stent restenosis within the venous outflow of grafts and fistula a prospective, randomized multicenter study also appeared to show better primary target lesion and circuit primary patency after stent-graft than after angioplasty alone [30]. A small, randomized trial showed improved primary patency for cephalic arch stenosis after stent graft deployment than after angioplasty alone [33]. A randomized trial on treatment of cephalic arch stenosis showed improved primary patency with stent grafts compared with bare metal stents [34].

Indications for endoluminal stent-graft placement include:

a. Treatment of arteriovenous graft (AVG) venous anastamotic stenosis.
b. Treatment of AVG or arteriovenous fistula (AVF) venous outflow in-stent restenosis.

Indications for either endoluminal stent-graft or bare stent placement include [37]:

a. Persistence of a significant venous stenosis, not at an AVG venous anastomosis, that has failed balloon angioplasty and surgical revision or new access is difficult, surgery is contraindicated, or there are limited remaining access sites [37].
b. A clinically significant, symptomatic central vein stenosis that has either failed balloon angioplasty or recurred within a 3-month period following an initially successful balloon angioplasty [1,37].
c. Rupture of an outflow vein following balloon angioplasty that cannot be controlled with balloon tamponade [37].
d. Flow-limiting dissection that persists despite prolongs balloon inflation.

II. INDICATIONS AND CONTRAINDICATIONS

A. Indications

3. Indications for Drug-Coated Balloon Angioplasty

Recent studies support use of drug-coated balloons for angioplasty of stenotic lesions in dialysis AVF. One randomized study [49] reported superiority of target-lesion primary patency with drug (paclitaxel)-coated balloon angioplasty compared to standard balloon angioplasty (82.2% versus 59.5%). In addition, the mean number of repeat interventions to maintain target-lesion primary patency during the 6 months after the index procedure was significantly less with drug-coated balloon angioplasty compared with standard angioplasty ($P < .001$). The circuit patency at 6 months of the index procedure was superior in patients who underwent drug-coated balloon angioplasty (73% versus 48%, $P < .001$). Given the cost of drug-coated balloons, more studies on cost-effectiveness of these devices in the overall care of dialysis patients is required. At present, it is reasonable to use drug-coated balloon angioplasty for stenotic lesions of AVF.

II. INDICATIONS AND CONTRAINDICATIONS

A. Indications

4. Indications for Treatment of Steal

Steal can manifest by high-output cardiac failure [50] or ischemic symptoms, ranging from mild numbness or coolness to significant paresthesias, pain, motor weakness, sensory loss, or tissue loss. This can be due to excessive flow within the fistula and/or an arterial stenosis limiting extremity blood flow. Diagnosis is primarily based on clinical signs and symptoms that can be supported by noninvasive testing. Catheter angiography may be performed to identify and treat a flow-limiting arterial lesion. 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 [51]. When there is no arterial lesion and excessive flow within the fistula, decreasing the flow in the graft or fistula via surgical means can also improve or relieve symptoms of steal [52]. Radiocephalic fistulae complicated by steal caused by retrograde flow within the radial artery distal to the anastomosis have been treated by distal radial artery occlusion, via either ligation [53] or endovascular occlusion [54].

Current indications for treatment of steal include:

1. Ischemic signs or symptoms in the limb ipsilateral to the access [38]
2. Signs or symptoms of high-output cardiac failure [38]

II. INDICATIONS AND CONTRAINDICATIONS

B. 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.

1. Absolute Contraindication [37]
   Active access infection [37]

2. Relative Contraindications [37]
   a. Severe contrast allergy [37]
   b. Need for emergent dialysis such as severe hyperkalemia or volume overload causing congestive heart failure [37]
   c. Right-to-left shunt [37]
   d. Need for access declotting in setting of severe cardiac and pulmonary disease [37]

III. 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. Regularly scheduled multidisciplinary conferences are one possible approach to ensuring optimum care of patients with vascular access complications.

III. QUALIFICATIONS AND RESPONSIBILITIES OF PERSONNEL

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 diagnostic imaging 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. The physician must have a thorough understanding of anatomy (including congenital and developmental variants and common collateral pathways), diagnostic imaging 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 experience and demonstrated competency as primary operator in diagnostic angiography under the direct supervision of an on-site, qualified physician, during which the physician performed diagnostic peripheral arteriograms, transluminal angioplasties, and EMDA angiographic procedures, as primary operator with documented success and complication rates that meet the threshold criteria listed in section X [55].
   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, 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) [56].

III. QUALIFICATIONS AND RESPONSIBILITIES OF PERSONNEL

B. Non-Physician Radiology Provider (NPRP)

NPRPs are all Non-Physician Providers (eg, RRA, RPA, RA, PA, NP, ...) who assist with or participate in portions of the practice of a radiologist-led team (Radiologists = diagnostic, interventional, neurointerventional radiologists, radiation oncologists, and nuclear medicine physicians). The term "NPRP" does not include radiology, CT, US, NM

MRI technologists, or radiation therapists who have specific training for radiology related tasks (eg, acquisition of images, operation of imaging and therapeutic equipment) that are not typically performed by radiologists.

The term 'radiologist-led team' is defined as a team supervised by a radiologist (ie, diagnostic, interventional, neurointerventional radiologist, radiation oncologist, and nuclear medicine physician) and consists of additional healthcare providers including RRAs, PAs, NPs, and other personnel critical to the provision of the highest quality of healthcare to patients. (ACR Resolution 8, adopted 2020).

NPRPs can be valuable members of the interventional radiology team. See the ACR–SIR–SNIS–SPR Practice Parameter for the Clinical Practice of Interventional Radiology [57].

III. QUALIFICATIONS AND RESPONSIBILITIES OF PERSONNEL

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, the American Board of Science in Nuclear Medicine (ABSNM), or the American Board of Medical Physics (ABMP).

A Qualified Medical Physicist should meet the ACR Practice Parameter for Continuing Medical Education (CME) [56].

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). (ACR Resolution 17, adopted in 1996 – revised in 2008, 2012, 2022, Resolution 41f)

III. QUALIFICATIONS AND RESPONSIBILITIES OF PERSONNEL

D. 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[1] 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[2] 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.

1 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, revised 2017 Resolution 12c)
2 See the ACR–SPR Practice Parameter for the Use of Intravascular Contrast Media.

III. QUALIFICATIONS AND RESPONSIBILITIES OF PERSONNEL

E. 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.

IV. 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 minimum:

1. A high-resolution image intensifier and television chain or flat panel detector with standard angiographic imaging capabilities. Last image hold and pulsed fluoroscopy can be used 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, stents, 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.

IV. SPECIFICATIONS OF THE EXAMINATION

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 and, if possible, an end-tidal carbon dioxide monitor should be available (see the ACR–SIR Practice Parameter for Minimal and/or Moderate Sedation/Analgesia [58]).
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.

IV. SPECIFICATIONS OF THE EXAMINATION

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 Minimal and/or Moderate Sedation/Analgesia [58]).

IV. SPECIFICATIONS OF THE EXAMINATION

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. Often this will be an acute-care hospital with adequate surgical, anesthesia, and ancillary support. When these procedures are performed in a freestanding outpatient center without such support, detailed protocols for the rapid transport or admission of patients to an acute-care hospital should be formalized in writing.

IV. SPECIFICATIONS OF THE EXAMINATION

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 and prior dialysis access interventions.
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. Informed consent as per the institutional guidelines, applicable state laws and the ACR–SIR–SPR Practice Parameter on Informed Consent for Image-Guided Procedures [59]

IV. SPECIFICATIONS OF THE EXAMINATION

E. Patient Care

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.
b. The organization should have processes and systems in place for reconciling differences in staff responses during the "time out."
c. All patients should have cardiac monitoring continuously during the procedure, with intermittent blood pressure monitoring. A record of vital signs should be maintained.
d. f the patient is to receive moderate sedation, pulse oximetry and CO2 capnography (if available) 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.
e. A physician or an advanced practice provider should be available during the immediate postprocedure period.

IV. SPECIFICATIONS OF THE EXAMINATION

E. Patient Care

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 Minimal and/or Moderate Sedation/Analgesia [58].

IV. SPECIFICATIONS OF THE EXAMINATION

F. Selection Criteria for Short-Term Observation

The duration of postprocedure observation is variable and depends on the type and extent of the procedure, choice of sedation/anesthesia, and the clinical condition of the patient.

V. DOCUMENTATION

Documentation and reporting should be in accordance with the ACR–SIR–SPR Practice Parameter for the Reporting and Archiving of Interventional Radiology Procedures [60].

VI. RADIATION SAFETY IN IMAGING

Radiologists, medical physicists, non-physician radiology providers**,** 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 who work with ionizing radiation must understand the key principles of occupational and public radiation protection (justification, optimization of protection, application of dose constraints and limits) and the principles of proper management of radiation dose to patients (justification, optimization including the use of dose reference levels). https://www-pub.iaea.org/MTCD/Publications/PDF/PUB1775_web.pdf

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

Facilities should have and adhere to policies and procedures that require ionizing radiation examination protocols (radiography, fluoroscopy, interventional radiology, CT) to vary according to diagnostic requirements and patient body habitus to optimize the relationship between appropriate radiation dose and adequate image quality. Automated dose reduction technologies available on imaging equipment should be used, except when inappropriate for a specific exam. If such technology is not available, appropriate manual techniques should be used.

Additional information regarding patient radiation safety in imaging is available from the following websites – Image Gently® for children (www.imagegently.org) and Image Wisely® for adults (www.imagewisely.org). 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 periodically measured by a Qualified Medical Physicist in accordance with the applicable ACR Technical Standards. Monitoring or regular review of dose indices from patient imaging should be performed by comparing the facility's dose information with national benchmarks, such as the ACR Dose Index Registry and relevant publications relying on its data, applicable ACR Practice Parameters, 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; 2006, 2009, amended 2013, revised 2023 (Res. 2d).

VII. 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 Quality Control & Improvement, Safety, Infection Control*, *and Patient Education* on the ACR website (https://www.acr.org/Advocacy-and-Economics/ACR-Position-Statements/Quality-Control-and-Improvement).

VIII. QUALITY IMPROVEMENT

Periodic monitoring of individual and group dialysis access intervention outcome metrics and complications should be a part of each facility's quality improvement program. Important outcome metrics include clinical success and primary and secondary patency rates as well as rates of major and minor complication. Metrics should be periodically reviewed to observe trends over time and identify areas for improvement. Published reported outcome metrics and complication rates are available for an external benchmark comparison; however, it is important to recognize that a practice's observed rates will be highly dependent on patient characteristics and local practice patterns [38].

ACKNOWLEDGEMENTS

This practice parameter was revised according to the process described under the heading *The Process for Developing ACR Practice Parameters and Technical Standards* on the ACR website (https://www.acr.org/Clinical-Resources/Practice-Parameters-and-Technical-Standards) by the Committee on Practice Parameters – Interventional and Cardiovascular Radiology of the ACR Commission on Interventional and Cardiovascular Radiology, in collaboration with the SIR.

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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.

Development Chronology for This Practice Parameter Adopted 2000 (Resolution 13)
Amended 2004 (Resolution 25)
Revised 2006 (Resolution 30, 16g, 17, 34, 35, 36)
Amended 2007 (Resolution 12m**,** 38)
Amended 2009 (Resolution 11)
Revised 2011 (Resolution 43)
Amended 2014 (Resolution 39)
Revised 2017 (Resolution 13)
Amended 2018 (Resolution 44)
Amended 2019 (Resolution 23)
Amended 2020 (Resolution 8)
Revised 2022 (Resolution 16)
Amended 2023 (Resolution 2c, 2d)