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Each practice parameter and technical standard, representing a policy statement by the College, has undergone a thorough consensus process in which it has been subjected to extensive review and approval. The practice parameters and technical standards recognize that the safe and effective use of diagnostic and therapeutic radiology requires specific training, skills, and techniques, as described in each document. Reproduction or modification of the published practice parameter and technical standard by those entities not providing these services is not authorized.

Revised 2017 (Resolution 29)*

ACR–SPR PRACTICE PARAMETER FOR THE PERFORMANCE OF RENAL SCINTIGRAPHY

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 care¹. 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 physician or medical physicist in light of all the circumstances presented. Thus, an approach that differs from the practice parameters, standing alone, does not necessarily imply that the approach was below the standard of care. To the contrary, a conscientious practitioner may responsibly adopt a course of action different from that set forth in the practice parameters when, in the reasonable judgment of the practitioner, such course of action is indicated by the condition of the patient, limitations of available resources, or advances in knowledge or technology subsequent to publication of the practice parameters. However, a practitioner who employs an approach substantially different from these practice parameters is advised to document in the patient record information sufficient to explain the approach taken.

The practice of medicine involves not only the science, but also the art of dealing with the prevention, diagnosis, alleviation, and treatment of disease. The variety and complexity of human conditions make it impossible to always reach the most appropriate diagnosis or to predict with certainty a particular response to treatment. Therefore, it should be recognized that adherence to these practice parameters will not assure an accurate diagnosis or a successful outcome. All that should be expected is that the practitioner will follow a reasonable course of action based on current knowledge, available resources, and the needs of the patient to deliver effective and safe medical care. The sole purpose of these practice parameters is to assist practitioners in achieving this objective.

¹ Iowa Medical Society and Iowa Society of Anesthesiologists v. Iowa Board of Nursing, ___ N.W.2d ___ (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 for Pediatric Radiology (SPR) to guide physicians performing renal scintigraphy in adult and pediatric patients. Renal scintigraphy involves the intravenous injection of a radiopharmaceutical, which is extracted from the blood by the kidneys and imaged using a gamma camera. Estimation of renal function using a well counter may be performed in conjunction with, or in lieu of, renal scintigraphy.

Properly performed, renal scintigraphy is a sensitive method for detecting, evaluating, and quantifying a variety of anatomic and physiologic abnormalities of the kidneys and urinary system. Pharmacologic manipulation may enhance the sensitivity and specificity in certain renal diseases. It also is possible to accurately quantify some parameters of renal function. Although certain patterns are suggestive of individual disease entities, correlation of abnormal findings with clinical information, radiographs, computed tomography, magnetic resonance imaging, and other radiopharmaceutical imaging and non-imaging examinations is frequently helpful for optimal diagnosis.

The goal of renal scintigraphy is to enable the interpreting physician to detect anatomic and/or functional abnormalities of the kidneys and/or urinary tract by producing images of diagnostic quality and/or reliable quantitative data.

Application of this parameter should be in accordance with the [ACR–SPR Technical Standard for Diagnostic Procedures Using Radiopharmaceuticals](#) [1].

II. INDICATIONS

General indications for renal scintigraphy include, but are not limited to, evaluation and/or quantification of:

1. Renal perfusion and function, including differential (also known as split or relative) renal function
2. Glomerular filtration rate (GFR)
3. Effective renal plasma flow (ERPF)

Specific indications for renal scintigraphy include, but are not limited to, detection, evaluation, and/or quantification of:

1. Urinary tract obstruction
2. Renovascular hypertension
3. Renal allograft perfusion and function and complications
4. Pyelonephritis and renal cortical scarring
5. Congenital and acquired renal abnormalities, including mass lesions

The [ACR–SPR Practice Parameter for Imaging Pregnant or Potentially Pregnant Adolescents and Women with Ionizing Radiation](#) provides useful information on radiation risks to the fetus regardless of source. Information on managing pregnant or potentially pregnant patients undergoing nuclear medicine procedures is available from the International Commission on Radiological Protection [2-4].

III. QUALIFICATIONS AND RESPONSIBILITIES OF PERSONNEL

See the [ACR–SPR Technical Standard for Diagnostic Procedures Using Radiopharmaceuticals](#) [1].

IV. SPECIFICATIONS OF THE EXAMINATION

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

Documentation that satisfies medical necessity includes 1) signs and symptoms and/or 2) relevant history (including known diagnoses). Additional information regarding the specific reason for the examination or a

provisional diagnosis would be helpful and may at times be needed to allow for the proper performance and interpretation of the examination.

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

A. Radiopharmaceuticals

Radiopharmaceuticals for evaluation of the kidneys may be classified into 3 broad categories.

1. Technetium-99m mercaptoacetyl triglycine (MAG3) [5]

a. Kinetics:

Rapid extraction by tubular cells with secretion into the renal collecting system. Renal uptake is reduced by poor renal perfusion and function but is not affected as severely as with technetium-99m DTPA.

b. Indications:

- i. Assess renal perfusion and differential function
- ii. Assess urinary tract obstruction
- iii. Assess renovascular hypertension
- iv. Assess renal allograft
- v. Estimate renal plasma flow ERPF

c. Administered Activity:

- i. Adults: Up to 370 MBq (10 mCi)
- ii. Children with angiographic phase: 5.55 MBq/kg (0.15 mCi/kg); Minimum 37 MBq (1 mCi) and Maximum 148 MBq (4 mCi) [6]²
- iii. Children without angiographic phase: 3.7 MBq/kg (0.10 mCi/kg); Minimum 37 MBq (1 mCi) and Maximum 148 MBq (4 mCi) [6]²

2. Technetium-99m diethylene triamine penta-acetic acid (DTPA)

a. Kinetics:

Predominant excretion by glomerular filtration. It can be used to estimate GFR. Renal excretion of DTPA is significantly affected by reduced renal perfusion and function.

b. Indications:

² Alternative pediatric radiopharmaceutical dosing is proposed as the EANM Dosage Card [5], which may also be found at http://www.eanm.org/publications/dosage_calculator.php?nav1d-285.

- i. Assess renal perfusion and differential function
 - ii. Assess urinary tract obstruction
 - iii. Assess renovascular hypertension
 - iv. Assess renal allograft
- c. Administered Activity:
- i. Adults: Up to 555 MBq (15 mCi)
 - ii. Children: 3.7 to 7.4 MBq/kg (0.1-0.2 mCi/kg). Minimum 37 MBq (1 mCi). Maximum 185 MBq (5 mCi) [6]²
 - iii. GFR without imaging: 7.4 to 18.5 MBq (0.20 to 0.50 mCi)
3. Technetium-99m dimercaptosuccinic acid (DMSA)

a. Kinetics:

This radiopharmaceutical is predominantly incorporated into renal tubular cells with a minor component of glomerular filtration. It is an excellent renal parenchymal imaging radiopharmaceutical that can be used for detecting and characterizing pyelonephritis and renal cortical scars.

Indications:

- i. Detect and define pyelonephritis or renal cortical scars
- ii. Assess renal shape, size, and position
- iii. Assess relative functional cortical mass (eg, differential/split/relative function)

Administered Activity:

- i. Adults: Up to 185 MBq (5 mCi)
- ii. Children: 1.85 MBq/kg (0.05 mCi/kg). Minimum 18.5 MBq (0.5 mCi). Maximum 100 MBq (2.7 mCi) [6]²

B. Radionuclide Renography

Radionuclide renography refers to serial imaging after intravenous administration of technetium-99m MAG3 or technetium-99m DTPA. A commonly used technique involves dynamic acquisition of 1 to 2 second images for 1 minute (angiographic or vascular phase), followed by 15 to 60 second images for 20 to 30 minutes (functional uptake, cortical transit, and excretion phases). If evaluation of renal perfusion is not needed, the examination is performed without the first angiographic/vascular phase.

Qualitative evaluation of regional renal perfusion, differential function, and cortical transit of radiopharmaceutical can be performed by visual analysis. Quantitative evaluation of cortical function and collecting system drainage is made using regions-of-interest that typically are applied to each whole kidney. A background region-of-interest is placed overlying soft tissue adjacent to each kidney. Differential renal function is calculated based on the relative counts accumulated in each kidney during the second minute after injection of the radiopharmaceutical. Occasionally, it may be helpful to approximate regions-of-interest to the renal cortex and the renal collecting system, although absolute segmentation of cortex and renal collecting system is difficult. If there is suspected ureteral obstruction or megaureter, regions-of-interest may be applied to the ureters. Depending on the regions-of-interest drawn, the time-activity curves will reflect the functional uptake/accumulation and clearance of radiopharmaceutical in the whole kidney, renal cortex, renal collecting system, or ureter.

C. Diuresis Renography

Diuresis renography can evaluate the severity of urinary tract obstruction and can differentiate an obstructed collecting system from a dilated but nonobstructed collecting system. It also is used for postoperative assessment of the functional and urodynamic results of corrective surgery.

Diuresis renography is performed by intravenous administration of a loop diuretic (usually furosemide, although other diuretics have been used) in conjunction with radionuclide renography. The usual dose of furosemide is 0.5 to 1.0 mg/kg (1 mg/kg in children), with a maximum dosage of 40 mg. Patients on chronic diuretic therapy likely will be unresponsive to a small dose of furosemide and typically are administered their usual dose of furosemide for diuretic renography. It can be helpful to coordinate timing of renography with the medication schedule to avoid starting the renal scintigraphic examination during a pre-existing diuresis.

It is important to ensure that the patient is well hydrated prior to performing diuresis renography. Intravenous fluid infusion is particularly useful in children and can be performed during the initial 20 minute renogram. A full or distended bladder can prolong renal collecting system drainage, and depending on clinical circumstances, an indwelling bladder catheter may be useful for adequate assessment of upper tract obstruction [8].

Different approaches to diuresis renography are characterized by the time of furosemide administration in relation to the time of radiopharmaceutical administration. The most commonly used approach (referred to as F+20) is intravenous administration of furosemide at or soon after the completion of 20minute (or 30 minute) radionuclide renography; dynamic 15 second to 60 second renal images are obtained for another 20 to 30 minutes. Other approaches include administering furosemide 15 minutes prior to radiopharmaceutical administration (F-15) or at the time of radiopharmaceutical administration (F-0). Region-of-interest analysis of the images obtained during the diuretic phase are used for quantitative analysis of collecting system drainage.

Diuresis renography usually is performed with the patient in the supine position. This may result in delayed clearance of the radiopharmaceutical from a dilated but nonobstructed collecting system. Therefore, an additional posterior static image after the patient has been in an upright position for 10 to 15 minutes may help to assess gravity-assisted clearance [8].

It is important to ensure that the patient is well-hydrated. Intravenous fluid infusion is particularly useful in children. A distended bladder may prolong renal collecting system drainage depending on clinical circumstances, an indwelling bladder catheter may be [8] necessary to assess adequately for obstruction of the upper tracts.

In children, particularly in neonates, the natural history of prenatal hydronephrosis and possible urinary tract obstruction can be variable. Multiple diuretic renograms over time may be needed to detect gradual improvement or worsening of urinary tract drainage. In neonates, renal function continues to mature after birth, and renal immaturity during the first few months after birth may delay uptake and clearance of tubular radiopharmaceuticals. Ideally, renography will be delayed until at least 3 months of age to allow for renal maturation. If this is not possible, then the diuretic renogram must be interpreted in the context of renal immaturity.

The natural history of hydronephrosis in children, particularly in neonates, is variable, and definitive diagnosis of obstructive uropathy on a single diuresis renogram is often difficult. Multiple examinations at appropriate intervals may be needed to detect gradual improvement or worsening of the postdiuresis drainage. Therefore, whatever technique is used, it should be standardized in order to allow meaningful comparison of the serial examinations in each patient

D. Captopril (ACE Inhibitor) Renography

Renovascular hypertension is caused by hemodynamically significant stenosis of the main renal artery or one of its branches. Most hypertension is essential (idiopathic), with less than 5% having a demonstrated renovascular etiology. The prevalence of renovascular hypertension is somewhat higher in patients with risk factors that include severe hypertension and end-stage renal disease [10]. However, renal artery stenosis may be present but not be the etiology of the patient's hypertension. Thus, the goal of ACE-1 renography is to identify the subgroup of patients in whom hypertension is due to renal artery stenosis and who could potentially respond to an intervention, such as revascularization [11].

Imaging assessment for renovascular hypertension, including scintigraphy, is most appropriate in patients in whom there is a high index of suspicion. Patients with a low index of suspicion usually have essential hypertension that can be well controlled medically, and in these patients imaging is not generally indicated.

In the presence of hemodynamically significant renal artery stenosis, renal perfusion pressure is reduced, activating the renin-angiotensin system. Angiotensin II causes selective constriction of the efferent arterioles and raises the pressure gradient across the glomerular capillary membrane. Because of this autoregulatory mechanism, the GFR is maintained and conventional renal scintigraphy may be normal. In these patients, administering angiotensin converting enzyme (ACE) inhibitors causes dilatation of the efferent arterioles. This leads to a significant but reversible decrease in GFR that is detectable on renal scintigraphy.

The choice of radiopharmaceutical, ACE inhibitor, and technique of examination varies among institutions. Technetium-99m MAG3 is preferred, but technetium-99m DTPA may be used. Renal scintigraphy is performed approximately 1 hour after oral administration of 25 to 50 milligrams of captopril or 10 to 20 minutes after intravenous injection of 40 micrograms/kg (maximum 2.5 mg) of Enalaprilat. The usual administered dosage of captopril in children is 1 mg/kg, with a maximum of 50 mg.

Food ingestion within 4 hours prior to captopril administration may decrease absorption and test accuracy [12]. Blood pressure should be measured before administration of the ACE inhibitor and monitored every 10 to 15 minutes. An intravenous line should be kept in place to allow prompt fluid replacement if the patient becomes hypotensive. Furosemide (0.25 mg/kg, maximum 20 mg) given intravenously at the time of radiopharmaceutical administration decreases radiopharmaceutical retention in the collecting systems and may facilitate detection of cortical retention of the radiopharmaceutical. The patient should be well hydrated, especially if furosemide will be used [12].

Chronic use of ACE inhibitors may decrease the sensitivity of ACE inhibitor renography. Ideally, ACE inhibitors are discontinued for 3 to 7 days before the test, depending on the half-life of the specific ACE inhibitor. If stopping the ACE inhibitor is not possible, the examination still may be performed [11,12].

One protocol is to perform a baseline scan without prior ACE inhibitor administration, followed (on the same or following day) by a second scan performed after administration of an ACE inhibitor [11]. Comparison of the 2 scans helps to detect subtle scintigraphic abnormalities produced by ACE inhibition.

An alternative protocol is to perform the first scan after administration of an ACE inhibitor [12]. A normal examination indicates a low probability for renovascular hypertension and obviates the need for a baseline examination without an ACE inhibitor. If the examination with an ACE inhibitor is abnormal, a baseline examination is performed on a following day.

With the use of intravenous Enalaprilat and technetium-99m MAG3 (but not technetium-99m DTPA), both the baseline and post-ACE inhibitor scans can be completed within 60 to 90 minutes. After administration of 1 to 3 mCi of technetium-99m MAG3, a baseline scan is performed for 20 to 30 minutes. Subsequently, 40 mg/kg (maximum 2.5 mg) of Enalaprilat is administered intravenously. Ten to twenty minutes later, 8 to 10 mCi of technetium-99m MAG3 is administered, and the second scan is performed for 20 to 30 minutes [13].

E. Evaluation of Renal Allografts

Renal scintigraphy has been deemed “usually appropriate” in the assessment of renal allograft dysfunction and as a postoperative screening examination for surgical complications. Technetium-99m MAG3 or technetium-99m DTPA may be used. Renal perfusion images are obtained using a technique similar to that outlined in section IV.B, except that an anterior projection is used and is centered over the lower abdomen and pelvis. It is possible to assess the presence or absence of renal perfusion, cortical infarcts, acute tubular necrosis, collecting system obstruction, urine leaks, nephrotoxic effect of medications (eg, cyclosporin A), and rejection. Comparison of serial examinations will enhance detection of subtle physiological changes [14,15].

F. Renal Cortical Imaging

The radiopharmaceutical for renal cortical imaging is technetium-99m DMSA. In most cases, optimal parenchymal imaging can be obtained 2 to 4 hours after radiopharmaceutical administration. If there is significant hydronephrosis, delayed imaging at 24 hours or administration of furosemide prior to delayed imaging may be helpful. If there is no retention of radiopharmaceutical in the collecting system, relative renal function can be calculated. When assessing differential renal function in children with vesicoureteral reflux, refluxed radiopharmaceutical may interfere with accurate quantification [16].

In adults, between 500,000 and 1,000,000 counts per image are desirable. At least 300,000 counts or 5 minutes per image should be used when imaging children [17]. A 256×256 matrix is preferred. Pinhole (4 mm aperture) images may be useful, especially in infants. Pinhole images should be acquired for a minimum of 100,000 to 150,000 counts or 10 minutes per image. At a minimum, posterior and both posterior oblique views should be obtained. When imaging a “horseshoe” or pelvic kidney, anterior images should also be obtained. Determination of differential renal function should be performed on the posterior planar image using a parallel-hole collimator. Background and depth corrections are optional. Depth correction, which can be accomplished by using the geometric mean, should be considered when there is a major variation or abnormality in the shape or location of the kidneys such as with a “horseshoe or pelvic kidney. Single photon emission computed tomography (SPECT) imaging also may be performed, although no definitive improvement in sensitivity has been demonstrated, and false-positive SPECT defects may decrease specificity [18].

G. Estimation of GFR

The radiopharmaceutical used for estimating GFR is technetium-99m DTPA. Numerous protocols are available, some of which involve imaging [5,17,19-21]. Whichever protocol is used, it is imperative that the technique is meticulous and that the protocol is followed assiduously.

H. Estimation of ERPF

Technetium-99m MAG3 does not provide a true ERPF measurement, but it provides a value that can be extrapolated to an ERPF equivalent measurement. Numerous protocols are available, some of which involve imaging [5,19,22]. Whichever protocol is used, it is imperative that the technique is meticulous and that the protocol is followed assiduously.

V. EQUIPMENT

A gamma camera with a parallel-hole collimator is required. When magnification is desired, a pinhole collimator may be used. For adults, a large-field-of-view gamma camera (400 mm) is desirable, but for children a small-field-of-view camera (250 to 300 mm) is acceptable. If a large-field-of-view camera is used in a pediatric patient, “zoom” or pinhole collimation may be used. For most situations using technetium-99m-labeled radiopharmaceuticals, low-energy all-purpose/general all-purpose (LEAP/GAP) collimators are sufficient. If renal cortical anatomic detail is desired, a high-resolution collimator will improve image quality, provided the count density is adequate.

For digital acquisition, a 128×128 matrix is the minimum necessary, but a 256×256 matrix may be preferred. SPECT (or SPECT/CT in adults) renal imaging using technetium-99m DMSA may be helpful in some circumstances.

VI. DOCUMENTATION

Reporting should be in accordance with the [ACR Practice Parameter for Communication of Diagnostic Imaging Findings](#) [23].

The report should include the radiopharmaceutical, administered activity, and route of administration, as well as any other pharmaceuticals administered, also with dosage and route of administration.

VII. RADIATION SAFETY

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

Facilities and their responsible staff should consult with the radiation safety officer to ensure that there are policies and procedures for the safe handling and administration of radiopharmaceuticals and that they are adhered to in accordance with ALARA. These policies and procedures must comply with all applicable radiation safety regulations and conditions of licensure imposed by the Nuclear Regulatory Commission (NRC) and by state and/or other regulatory agencies. Quantities of radiopharmaceuticals should be tailored to the individual patient by prescription or protocol

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.

Additional information regarding patient radiation safety in imaging is available at the Image Gently[®] for children (www.imagegently.org) and Image Wisely[®] for adults (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).

Nuclear medicine and molecular imaging examinations should administer the lowest activity to obtain images of diagnostic quality. National initiatives have partnered to provide such dosage optimization for adults and dosage optimizing calculators for pediatric patients. The following is a web link for this information and several references: www.imagegently.org. For further information, see the [ACR–AAPM Practice Parameter for Reference Levels and Achievable Administered Activity for Nuclear Medicine and Molecular Imaging](#) [6,24,25].

VIII. 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>).

Equipment performance monitoring should be in accordance with the [ACR–AAPM Technical Standard for Medical Nuclear Physics Performance Monitoring of Gamma Cameras](#) [26].

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 (<http://www.acr.org/guidelines>) by the Committee on Practice Parameters and Technical Standards – Nuclear Medicine and Molecular Imaging of the ACR Commission on Nuclear Medicine and Molecular Imaging and the Committee on Practice Parameters – Pediatric Radiology of the ACR Commission on Pediatric Radiology, in collaboration with and the SPR.

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*Practice guidelines 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 guidelines and technical standards published before 1999, the effective date was January 1 following the year in which the practice or technical standard was amended, revised, or approved by the ACR Council.

Development Chronology for this Practice Parameter

1995 (Resolution 30)
 Revised 1998 (Resolution 19)
 Revised 2003 (Resolution 16)
 Amended 2006 (Resolution 35)
 Revised 2008 (Resolution 12)
 Revised 2013 (Resolution 51)
 Amended 2014 (Resolution 39)
 Revised 2017 (Resolution 29)