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Amended 2014 (Resolution 39)\*

## **ACR–SPR PRACTICE PARAMETER FOR THE PERFORMANCE OF RENAL SCINTIGRAPHY**

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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 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.

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<sup>1</sup> 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 means for detecting, evaluating, and quantifying a variety of renal disorders. Pharmacologic manipulation may enhance the sensitivity and specificity in certain renal diseases. It also is possible to accurately quantify some guidelines of renal function. As with all scintigraphic examinations, correlation of findings with the results of other imaging and nonimaging procedures, as well as with clinical information, is imperative for maximum diagnostic yield.

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

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

## II. INDICATIONS

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

1. Renal function.
2. Congenital and acquired renal abnormalities, including mass lesions.
3. Urinary tract obstruction.
4. Renovascular hypertension.
5. Pyelonephritis and parenchymal scarring.
6. Renal allografts.
7. Guidelines of renal function, including effective renal plasma flow (ERPF), glomerular filtration rate (GFR), and differential (also known as split or relative) renal function.

For the pregnant or potentially pregnant patient, see the [ACR–SPR Practice Parameter for Imaging Pregnant or Potentially Pregnant Adolescents and Women with Ionizing Radiation](#).

## III. QUALIFICATIONS AND RESPONSIBILITIES OF PERSONNEL

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

## 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. Tubular radiopharmaceuticals: mainly cleared by tubular secretion [1]
  - a. Technetium-99m mercaptoacetyl triglycine (MAG3)

This radiopharmaceutical is rapidly extracted and secreted by tubular cells in a manner that is qualitatively similar to the action of orthoiodohippurate (OIH). Renal uptake of MAG3 is reduced by poor function but not as severely as with technetium-99m DTPA. MAG3 may be used quantitatively or qualitatively for evaluating obstructive uropathy, renovascular hypertension, and renal allografts and has been used to estimate ERPF. Administered activity of up to 10 millicuries (370 MBq) is used for adults. Administered activity for children should be determined based on body weight and should be as low as reasonably achievable for diagnostic image quality.<sup>1</sup> Pediatric administered activity ranges from 0.05 to 0.1 millicuries (1.85 to 3.7 MBq) per kilogram, with a minimum of 0.5 millicuries (18.5 MBq) and a maximum of 5.0 millicuries (185 MBq)<sup>2</sup> [2].
2. Glomerular radiopharmaceuticals: mainly cleared by glomerular filtration
  - a. Technetium-99m diethylene triamine penta-acetic acid (DTPA)

This radiopharmaceutical is excreted predominantly by glomerular filtration and can be used to measure GFR. Excretion by the kidneys is significantly affected by reduced renal function. The radiopharmaceutical may be used to assess renal blood flow and function, renal allografts, renovascular hypertension, and obstructive uropathy. For dynamic renal scintigraphy, administered activity of up to 15 millicuries (555 MBq) may be given to adults. If the examination is performed for calculation of GFR without imaging, the administered activity may be reduced to 0.20 to 0.50 millicurie (7.4 to 18.5 MBq). Administered activity for children should be determined based on body weight and should be as low as reasonably achievable for diagnostic image quality.<sup>1</sup> For children, administered activities are typically in the range of 0.1 to 0.2 millicurie (3.7 to 7.4 MBq) per kilogram, with a minimum of 1.0 millicurie (37 MBq) and a maximum of 5.0 millicuries [2] (185 MBq).
  - b. Iodine-125 iothalamate  
This radiopharmaceutical is used in administered activities of 0.01 to 0.05 millicurie (0.37 to 1.85 MBq) for the nonimaging assessment of GFR.
3. Cortical radiopharmaceuticals: primarily incorporated by tubular cells
  - a. Technetium-99m dimercaptosuccinic acid (DMSA)

This radiopharmaceutical is predominantly incorporated by renal tubular cells with a minor component of glomerular filtration. It is an excellent parenchymal imaging radiopharmaceutical, primarily used for detecting and defining pyelonephritis and renal cortical scars. Technetium-99m DMSA is also used to assess the size, shape, position, and relative functional cortical mass of the kidneys. Administered activity of up to 5.0 millicuries (185 MBq) may be given to adults. Administered activity for children should be determined based on body weight and should be as low as reasonably achievable for diagnostic image quality. For children, an administered activity of 0.05 to 0.1 millicurie (1.85 to 3.7 MBq) per kilogram is usually given, with a minimum of 0.3 millicurie (11.1 MBq) and a maximum of 3.0 millicurie (111 MBq)<sup>2</sup> [2].

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<sup>2</sup>For more specific guidance on pediatric dosing, please refer to the *Pediatric Radiopharmaceutical Administered Doses: 2010 North American Consensus Guidelines* [9]

## B. Radionuclide Renography

Radionuclide renography refers to serial imaging after intravenous administration of technetium-99m DTPA or technetium-99m MAG3. It is used for qualitative and quantitative evaluation of differential renal function. A commonly used technique involves dynamic acquisition of 1-2 second images for 1 minute (vascular phase), followed by 15-60 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 phase.

The regions of interest are typically drawn around the whole kidneys, but occasionally are limited to the renal cortex if a considerable amount of collecting system activity is present. A background region of interest is placed adjacent to each kidney. Depending on the regions of interest drawn, the time-activity curves will reflect the functional clearance of the whole kidney, renal cortex, or collecting system. The differential renal function is calculated based on the relative counts accumulated in each kidney during the second minute after injection of the radiopharmaceutical.

## C. Diuresis Renography

Diuresis renography is used to differentiate a dilated but nonobstructed collecting system from a dilated system with urodynamically significant obstruction. It is also useful for assessing functional and urodynamic results of corrective surgery.

A commonly used technique includes intravenous administration of technetium-99m MAG3 or technetium-99m DTPA and acquisition of dynamic 15-60 second posterior renal images for 20 to 30 minutes [3,4]. Furosemide, 0.5 mg/kg (1 mg/kg for children) with a maximum dose of 40 mg, is then administered intravenously, and dynamic 15-60 second renal images are obtained for another 20 to 30 minutes (F+20). Other techniques include administering furosemide 15 minutes prior to (F-15) or at the time of (F0) radiopharmaceutical administration. The initial set of images is used for evaluating differential renal function. The images obtained after administration of furosemide are used for quantitative analysis of postdiuresis clearance of the radiopharmaceutical from the dilated collecting system(s). Regions of interest, including the entire dilated collecting system(s), are drawn and a background subtracted time-activity curve is generated.

Diuresis renography is usually performed with the patient in the supine position. This may cause delayed clearance of the tracer from some dilated but nonobstructed collecting systems. Therefore, an additional posterior static image after the patient has been in an upright position for 10 to 15 minutes will help to assess gravity-assisted clearance [3].

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 necessary to assess adequately for obstruction of the upper tracts [3].

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 renal artery or one of its branches. However, renal artery stenosis may be present but not be the etiology of the patient's hypertension. Therefore, the goal of renal scintigraphy in the evaluation of hypertensive patients is to identify those who have renal artery stenosis with associated renin-dependent hypertension and would benefit from revascularization [5].

In the presence of hemodynamically significant renal artery stenosis, renal perfusion pressure is reduced, resulting in activation of 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, blockade of the conversion of angiotensin I to angiotensin II by 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 dose 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 [6]. 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 is used [6].

One protocol is to obtain a baseline scan without an ACE inhibitor followed by a repeat examination after administration of an ACE inhibitor on the same or following day [5]. The combined examinations help to detect subtle ACE inhibitor induced scintigraphic abnormalities.

An alternative protocol is to obtain the examination with an ACE inhibitor first [6]. 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 obtained the next day or later.

Chronic use of ACE inhibitors may decrease the sensitivity of the test. ACE inhibitors should be discontinued for 3 to 7 days before the test, depending on their half-life. If stopping the patient's ACE inhibitor is not possible, the study may still be performed [5,6].

#### E. Evaluation of Renal Allografts

Technetium-99m MAG3 or technetium-99m DTPA may be used for evaluating renal allografts. Renal perfusion images are obtained using a technique similar to that outlined in section V.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, urine leaks, infarcts, lymphoceles, hematomas, acute tubular necrosis, obstruction, nephrotoxic effect of medications (e.g., cyclosporin A), and rejection. Comparison of serial examinations will enhance detection of subtle physiological changes [7,8].

#### 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 injection. If there is significant hydronephrosis, delayed images at 24 hours or administration of furosemide prior to delayed imaging may be helpful. If there is no retention of tracer 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 [9].

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 [10]. A 256 x 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. Single-photon-emission computed tomography (SPECT) imaging may also be performed, although no definitive improvement in sensitivity has been demonstrated, and false-positive SPECT defects may decrease specificity [11]. 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.

#### G. Estimation of GFR

The radiopharmaceuticals used for estimating GFR are technetium-99m DTPA and iodine-125 iothalamate. Numerous protocols are available, some of which involve imaging [1,10,12-14]. 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 [1,12,15,16]. 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 also 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 tracers, 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 x 128 matrix is the minimum necessary, but a 256 x 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](#).

The report should include the radiopharmaceutical used and the administered activity and route of administration, as well as any other pharmaceuticals administered, also with dose 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/p1531interim\\_web.pdf](http://www-pub.iaea.org/MTCD/Publications/PDF/p1531interim_web.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<sup>®</sup>, 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<sup>®</sup> for children ([www.imagegently.org](http://www.imagegently.org)) and Image Wisely<sup>®</sup> 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).

## **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 Technical Standard for Medical Nuclear Physics Performance Monitoring of Gamma Cameras.

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