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ACR PRACTICE GUIDELINE FOR THE PERFORMANCE OF ADULT AND PEDIATRIC RENAL SCINTIGRAPHY

PREAMBLE

These guidelines are an educational tool designed to assist practitioners in providing appropriate radiologic care for patients. They are not inflexible rules or requirements of practice and are not intended, nor should they be used, to establish a legal standard of care. For these reasons and those set forth below, the American College of Radiology cautions against the use of these guidelines 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 guidelines, 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 guidelines when, in the reasonable judgment of the practitioner, such course of action is indicated by the condition of the patient, limitations on available resources or advances in knowledge or technology subsequent to publication of the guidelines. However, a practitioner who employs an approach substantially different from these guidelines 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. It should be recognized; therefore, that adherence to these guidelines 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 guidelines is to assist practitioners in achieving this objective.

I. INTRODUCTION

This guideline has been developed by the American College of Radiology (ACR) to guide interpreting physicians performing renal scintigraphy in adult and pediatric patients. Renal scintigraphy involves the intravenous injection of a radiopharmaceutical, which is extracted from the bloodstream by the kidneys, and subsequent imaging on a gamma camera, with computer acquisition. Quantitative functional studies using a well counter to assay blood and/or urine samples may be obtained in conjunction with renal scintigraphy.

Properly performed, renal scintigraphy is a sensitive means for detecting, evaluating, and quantifying numerous renal conditions. Pharmacologic manipulation may enhance the sensitivity of detecting and evaluating certain disease states. It also is possible to accurately quantify some parameters of renal function. As with all

scintigraphic studies, correlation of findings with the results of other imaging and non-imaging procedures, as well as with clinical information, is imperative for maximum diagnostic yield.

Application of this standard should be in accordance with the ACR Technical Standard for Diagnostic Procedures Using Radiopharmaceuticals.

(For pediatric considerations see Sections IV.A-C. and V.)

II. GOAL

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

III. INDICATIONS

Clinical indications for renal scintigraphy include, but are not limited to: detection, evaluation, and quantification of possible urinary tract obstruction; detection and evaluation of renovascular disease; detection of pyelonephritis and parenchymal scarring; detection and evaluation of functional and anatomic abnormalities of transplanted kidneys; qualitative measurement of renal function; detection of congenital and acquired anatomic renal abnormalities; and quantification of certain parameters of renal function, such as effective renal plasma flow (ERPF), excretory index, glomerular filtration rate (GFR), and differential renal function.

IV. SPECIFICATIONS OF THE EXAM

A. Radiopharmaceuticals

1. Technetium-99m diethylenetriamine penta-acetic acid (DTPA)

   This agent is excreted predominantly by glomerular filtration and can be used to measure GFR. Accumulation by the kidneys is significantly affected by reduced renal function. The agent may be used to assess renal blood flow and function, renal transplants, suspected renovascular hypertension, and obstructive uropathy. Administered activity of up to 25 millicuries (925 MBq) may be given to adults. For children, administered activities are typically in the range of 200 microcuries (7.4 MBq) per kilogram, with a minimum of 2.0 millicuries (74 MBq) and a maximum of 15.0 millicuries (555 MBq). If a blood-flow study is not required, administered activity may be reduced to as low as 60 microcuries (2.22 MBq) per kilogram, with a minimum of 300 microcuries (11.1 MBq).

2. Technetium-99m dimercaptosuccinic acid (DMSA)

   This agent is bound by renal tubules, with a small amount of glomerular filtration. It is an excellent parenchymal imaging agent. Technetium-99m DMSA may be used to assess the size, shape, position, and relative cortical mass of the kidneys. It may also be used in detecting pyelonephritis and renal cortical scars. Administered activity of up to 5.0 millicuries (185 MBq) may be given to adults. For children, an administered activity of 50 microcuries (1.85 MBq) per kilogram is usually given, with a minimum of 300 microcuries (11.1 MBq) and a maximum of 5.0 millicuries (185 MBq).

3. Technetium-99m glucoheptonate (GHA)

   This agent is partly bound by tubules and partly excreted by glomerular filtration. Its ability to localize in the kidney is moderately impaired by reduced renal function. Technetium-99m GHA may be used qualitatively for evaluating obstructive uropathy; the size, shape, and position of focal parenchymal scars and pyelonephritis; and the relative cortical mass of kidneys. Administered activity of up to 15 millicuries (555 MBq) may be used in adults. Pediatric administered activities are usually 70-100 microcuries (2.59-3.7 MBq), per kilogram, with a minimum of 500 microcuries (18.5 MBq) and a maximum of 10.0 millicuries (370 MBq).

4. Technetium-99m mercaptoacetyl triglycine (MAG3 ®)

   This agent is rapidly extracted and secreted by tubular cells in a manner that is qualitatively similar to the action of ortho-iodohippurate (OIH). Renal uptake is reduced by poor function but not as severely as with technetium-99m DTPA or technetium-99m GHA. The agent may be used quantitatively or qualitatively for evaluating obstructive uropathy, renovascular hypertension, and renal transplant abnormalities and has been used to approximate ERPF measurement. Administered activity of up to 10 millicuries (370 MBq) is employed for adults. Pediatric administered activity range from 50-100 microcuries (1.85-3.7 MBq) per kilogram, with a minimum of 400 microcuries (14.8 MBq) and a maximum of 5.0 millicuries (185 MBq).

5. Iodine-125 iothalamate (Glofil™)

   Iodine-125 iothalamate is used in dosages of 10-50 microcuries (37-1.85 MBq) for the nonimaging assessment of GFR.

B. Renal Parenchymal Imaging

The preferred agents are technetium-99m DMSA and technetium-99m GHA. In most cases, optimal parenchymal imaging can be obtained 1-3 hours after injection. By this time, collecting system activity will usually not be present. If there is no retention of tracer in the collecting system, relative renal function can be calculated. When assessing differential renal mass or function in children with vesicoureteral reflux, refluxed radiotracer may interfere with accurate quantification. Placement of an indwelling catheter to optimize drainage may be used to minimize this interference. If GHA is used, the differential function may be obtained from the nephrogram phase (1-3 minutes postinjection) or on delayed images.

Between 500,000 and 1,000,000 counts per image are desirable. Fewer counts per image may be used when studying children. At a minimum, both posterior and posterior oblique views should be obtained. When imaging a "horseshoe" or pelvic kidney, anterior images should be obtained. Single photon emission computed tomography (SPECT) imaging can also be obtained using these agents.

C. Renal Scintigraphy for Obstructive Uropathy

Renal scintigraphy can be used to differentiate a dilated but nonobstructed collecting system from a system that has a urodynamically significant obstruction. Suitable agents are technetium-99m MAG3, technetium-99m DTPA, and technetium-99m GHA. Sequential static images of the kidneys should be obtained every 15-60 seconds in the posterior projection for 20-30 minutes. Longer imaging times may be required if renal function is impaired.

Evaluation of washout of radiotracer from the collecting system may be very useful. A framing rate of one image every 15-30 seconds is acceptable. Background subtracted time-activity curves derived from regions of interest (ROIs) drawn around the renal cortex will yield information on peak renal parenchymal concentration. ROIs around the entire kidney can also be used. ROIs around the urinary collecting system will provide information about the half-time washout of tracer from the collecting system. The diuretic renogram is usually more definitive whenever there is radiotracer retained within the renal collecting system at the time furosemide is administered.

Intravenous administration of furosemide, 0.0-0.5 mg/kg with a usual maximum dose of 50 mg for adults (1.0 mg/kg with a maximum dose of 40 mg for children), given as soon as good tracer accumulation within the dilated pelvocalyceal system has occurred, followed by additional imaging, will often differentiate between an obstruction to urine drainage versus a dilated nonobstructed collecting system. If renal function is impaired or the patient is dehydrated, the response to furosemide may be blunted. Prolonged urinary tracer washout may also occur after pyeloplasty and in patients with markedly dilated collecting systems. A washout half time of less than 10 minutes is normal**.**

It is important to assure that the patient is well hydrated. Intravenous fluid infused at a prescribed rate is particularly useful in children. A distended bladder may also prolong renal collecting system drainage. Depending on clinical circumstances, a bladder catheter may be necessary to assess adequately for obstruction of the upper tracts. Further drainage may occur by having the patient upright for 3-5 minutes.

D. Renovascular Hypertension

Technetium-99m MAG3 or technetium-99m DTPA may be used. A renal blood-flow study may be performed during the first 30-60 seconds of the exam. Images are obtained in the posterior projection. If quantification of the flow study is desired, the framing rate should be one or two frames per second.

Acquisition of data for the parenchymal phase, both analog and digital, is similar to that described for obstructive uropathy in Section IV.C. Furosemide (0.25 mg/kg) given intravenously at the time of tracer administration may be useful to decrease collecting system tracer retention and facilitate quantification of parenchymal transit. The patient should be well hydrated, especially if furosemide is used.

To enhance sensitivity, the examination may be performed after administration of an angiotensin-converting enzyme (ACE) inhibitor, such as Captopril™ or enalaprilat. Several protocols have been described. The dose of Captopril™ is usually 25-50 mg orally, and the dose of enalaprilat is 0.4 mg/kg intravenously with a maximum of 2.5 mg. When using technetium-99m MAG3, a renogram curve showing a prolonged time to peak activity and delayed washout suggests renovascular hypertension. Diminished GFR and/or ERPF values may also indicate renovascular hypertension.

Caution in the use of ACE inhibitors should be exercised. The patient's blood pressure must be monitored, and an intravenous line should be kept in place to allow prompt

fluid replacement if the patient becomes hypotensive following ACE inhibitor administration.

The patient should discontinue ACE inhibitors for at least 48 hours. If stopping the patient's ACE inhibitor for 48 hours or more is not possible, the study may still be performed. The sensitivity and specificity for detecting renovascular hypertension may be decreased.

E. Evaluation of Renal Transplants

Technetium-99m MAG3, technetium-99m DTPA or technetium-99m GHA. may be used. A renal blood-flow study is performed during the first 60 seconds of the exam using a technique similar to that outlined in Section IV.D., except that the anterior projection is employed. Sequential renal images are then obtained in the anterior projection over a period of 20 minutes or longer, in a manner otherwise similar to that outlined in Section IV.C. It is possible to assess the presence or absences of renal blood flow, urine leaks, transplant infarcts, lymphoceles, hematomas, acute tubular necrosis, obstruction, nephrotoxic effect of medications (e.g., cyclosporin A), and renal transplant rejection. Comparison of serial exams will enhance detection of subtle physiological change.

F. Estimation of GFR

The radiopharmaceuticals of choice are technetium-99m DTPA and iodine-125 iothalamate. Numerous protocols are available, some of which involve imaging. Whichever protocol is used, it is imperative that the technique be meticulous and that the procedure is followed assiduously.

G. Estimation of ERPF

Technetium-99m MAG3 does not give a true ERPF measurement but results in a number that can be extrapolated to an ERPF-like value. Numerous protocols are available, some of which involve imaging. Whichever protocol is used, it is imperative that the technique is meticulous and that the procedure is followed assiduously.

V. EQUIPMENT

A gamma camera equipped with a parallel-hole collimator is required. When magnification is desired, a converging or pinhole collimator may be used. For adults, a large-field-of-view scintillation camera (400 mm) is desirable, but for children a small-field-of-view camera (250-300 mm) is also acceptable. If a large-field-of-view camera is employed 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.

If digital acquisition is desired, a 64 x 64 acquisition matrix is the minimum necessary, and 128 x 128 may permit more reliable quantification.

SPECT renal imaging using technetium-99m DMSA or technetium-99m GHA may be helpful in some circumstances.

VI. DOCUMENTATION

Reporting should be in accordance with the ACR Practice Guideline for Communication: Diagnostic Radiology.

VII. QUALITY CONTROL AND IMPROVEMENT, SAFETY, INFECTION CONTROL, AND PATIENT EDUCATION CONCERNS

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 Concerns appearing elsewhere in the ACR Practice Guidelines and Technical Standards book.

Equipment performance monitoring should be in accordance with the ACR Technical Standard for Medical Nuclear Physics Performance Monitoring of Nuclear Medicine Imaging Equipment.

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