

Society of Nuclear Medicine Procedure Guideline for Renal Cortical Scintigraphy in Children

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I. Purpose

The purpose of this guideline is to assist nuclear medicine practitioners in recommending, performing, interpreting, and reporting the results of renal cortical scintigraphy in children.

II. Background Information and Definitions

Renal cortical scintigraphy is used for the detection of the cortical defects of acute pyelonephritis and scarring related to chronic pyelonephritis. Cortical scintigraphy is able to detect twice as many defects as ultrasound and 4 times as many defects as intravenous urography. The loss of function associated with acute pyelonephritis, when detected early and satisfactorily treated, can be reversed without scar formation. The sequelae of renal infection can be monitored by follow-up cortical scintigraphy. Computed tomography has sensitivity and specificity similar to those of cortical scanning for the detection of acute pyelonephritis but adds to the risk of contrast reaction and has a higher radiation exposure. Magnetic resonance imaging is a promising but expensive nonionizing method of visualizing pyelonephritis.

The commonly used clinical and laboratory parameters are not reliable for the diagnosis of acute pyelonephritis. The presenting symptoms can be varied and sometimes confusing. Patients may present with fever, flank pain or tenderness, malaise, irritability, leukocytosis, and bacteriuria, but there may be no definite indication of renal parenchymal infection. Neonates in particular present with non-specific clinical findings. The higher grades of vesicoureteral reflux are generally associated with a greater risk for the development of pyelonephritis.

However, acute pyelonephritis in the absence of vesicoureteral reflux is seen frequently.

III. Common Indications

- A. Acute pyelonephritis
- B. Renal scarring
- C. Relative functioning renal mass
- D. Solitary or ectopic renal tissue (e.g., pelvic kidney)
- E. Horseshoe and pseudohorseshoe kidneys
- F. Allergy to iodinated contrast agents

IV. Procedure

A. Patient Preparation

1. Preparation before arrival in the department:
 - a. No preparation is necessary if sedation is not required for performance of the study. Some infants and young children will fall asleep if sleep deprived for several hours and fed just before the delayed imaging.
 - b. An informed consent, patient preparation, and pre-sedation evaluation are necessary for administration of sedation.
 - i. Sedation may have to be administered for the performance of procedures that require the younger child or uncooperative older child to remain motionless for a prolonged period of time.
 - ii. High-resolution pinhole collimation and single-photon emission computed tomography (SPECT) require prolonged imaging times (30 min or more), and motion obscures the presence of defects in the cortex of the kidneys.

- iii. Details of pediatric sedation can be referenced from the Society of Nuclear Medicine *Procedure Guideline for Pediatric Sedation in Nuclear Medicine* and the guidelines published by the American Academy of Pediatrics.
 2. Preparation before injection of the radiopharmaceutical:
 - a. The procedure is explained to parents and to children old enough to understand.
 - b. Continual communication and reassurance with explanation of each step are essential for cooperation and successful intravenous injection of the radiopharmaceutical.
- B. Information Pertinent to Performing the Procedure
 1. History of prior surgery to the urinary tract, congenital urinary abnormalities (duplex systems, ectopic renal tissue, renal fusion, etc.), urinary tract obstruction, and question of mass lesion is important for accurate interpretation.
 2. Review of available past radiographic, ultrasound, and radionuclide studies adds to the accuracy of interpretation of the current study.
 3. History to evaluate for allergic reactions and previous complications to sedation.
- C. Precautions

Patients with renal tubular acidosis show reduced tubular concentration of ^{99m}Tc -dimercaptosuccinic acid (DMSA) and increased excretion in the urine.
- D. Radiopharmaceutical
 1. ^{99m}Tc -DMSA is bound to proximal tubular cells with 40%–65% of the injected dose present in the cortex 2 h after the injection. The greater amount of activity in the cortex permits better resolution of cortical defects. ^{99m}Tc -DMSA is preferred in small infants.
 2. ^{99m}Tc -glucoheptonate (GH) is partially concentrated and excreted in the urine and partially bound to the renal tubules with 10%–20% of the injected dose present in the proximal convoluted tubules of the cortex 2 h after injection.
 - a. 40%–65% of the radiopharmaceutical is handled by glomerular filtration, permitting dynamic imaging.
 - b. Acquisition of dynamic and static images may be performed immediately and within 20–30 min after the injection of the radiopharmaceutical.
 3. Delayed imaging is suggested 2–4 h after the injection of the radiopharmaceutical. With poor renal function or clearance, even further delayed imaging will increase lesion definition.
 4. Delayed imaging (up to 24 h after the injection) may be necessary for quantitation of split renal function when there is a severely obstructed collecting system.
- E. Image Acquisition
 5. The renal cortical exposure to the kidneys is equivalent for both radiopharmaceuticals if there is adherence to the suggested doses. ^{99m}Tc -DMSA provides a lower gonadal and bladder exposure.
 6. Hepatic and biliary activity may be a problem in patients with poor renal function in renal cortical scintigraphy.
 7. The minimal administered activity for ^{99m}Tc -DMSA is ~11 MBq (0.3 mCi). The maximum administered activity for ^{99m}Tc -DMSA is ~110 MBq (3.0 mCi).
 8. The minimal administered activity for ^{99m}Tc -GH is ~20 MBq (0.5 mCi). The maximum administered activity for ^{99m}Tc -GH is ~300 MBq (8.0 mCi).

Radiation Dosimetry for Children (5 Years Old)

Radiopharmaceutical	Administered Activity MBq/kg (mCi/kg)	Organ Receiving the Largest Radiation Dose mGy/MBq (rad/mCi)	Effective Dose mSv/MBq (rem/mCi)
^{99m} Tc- dimercaptosuccinic acid	1.5–1.9 (0.04–0.05)	Kidneys 0.45* (1.67)	0.039 (0.14)
^{99m} Tc-glucoheptonate	3.0–4.4 (0.08–0.12)	Bladder wall 0.15† (0.56)	0.024 (0.089)

*Treves ST. *Pediatric Nuclear Medicine*. 2nd ed. New York, NY: Springer-Verlag; 1995: 5679–5690.

†International Commission on Radiological Protection. *Radiation Dose to Patients from Radiopharmaceuticals*. ICRP report 53. London, UK: ICRP; 1988:194.

F. Interventions

1. An indwelling venous catheter may be necessary in younger children (less than 4 y of age) or in older children who are unable to cooperate in remaining motionless for a prolonged period of time. The venous access allows injection of the radiopharmaceutical as well as the injection of intravenous sedation or diuretic, if needed, without the necessity for additional percutaneous injections.
2. The use of cortical agents allows either vesicoureteral reflux or retained activity in the collecting systems to interfere with the interpretation of the percent differential renal function.
 - a. Retained activity in the collecting system can be caused by a backpressure effect of a very distended neurogenic bladder and may be prevented by catheterization and continuous drainage.
 - b. In the case of a capacious collecting system or obstructed system, a diuretic (furosemide) can be administered before the delayed imaging or the patient can return for imaging up to 24 h after the injection of the radiopharmaceutical.
3. Acute pyelonephritis may appear as single or multiple defects.
 - a. The cortical defect may have reduced or absent localization of tracer with indistinct margins that do not deform the renal contour.
 - b. A localized increase in volume of a single affected area or a diffusely enlarged kidney with multiple defects may occur.
4. A mature cortical scar may have relatively sharp edges with contraction and reduced volume of the affected cortex.
 - a. Scarring can manifest as cortical thinning, flattening, or an ovoid or wedge-shaped defect.
 - b. The defect may become more obvious with growth of normal surrounding cortex.
 - c. The scan defect related to acute pyelonephritis may resolve in a variable period of time, depending on the severity of infection. A follow-up of 6–9 mo may be recommended after therapy.
5. Acute and chronic pyelonephritis or scarring cannot always be distinguished on the cortical scan.

G. Processing

For determination of percent differential function, regions of interest of each kidney and background area are outlined on the computerized posterior image.

H. Interpretation Criteria

1. DMSA localization is usually not seen in the medulla or the collecting system.
2. The split function normally varies from

I. Reporting

1. The procedure, the date of the study, amount and route of administration of the radiopharmaceutical (including diuretic if administered), and previous study for comparison are included.
2. The history includes the symptoms and/or diagnosis.
3. The technique includes time of imaging as

well as pinhole collimation or SPECT.

4. The findings should include the position, size, and overall morphology of functioning renal tissue; split renal function; the size, number, and location of areas of cortical loss; and the distinguishing of acute versus chronic pyelonephritis, if possible.

J. Quality Control

Air introduced into the reaction vial can degrade the DMSA complex, resulting in decreased renal uptake and increased hepatic and background activity.

K. Sources of Error

1. The flattening of the superolateral aspect of the left kidney may be attributed to the splenic impression.
2. Exaggerated contrast between intervening parenchyma and the renal poles suggests erroneously bipolar hypoactivity.
3. Linear area of absent tracer uptake (inter-renal septum) extending from the renal hilum into the parenchyma is seen on SPECT and may be confused with scar.
4. Interobserver reproducibility is decreased with SPECT.

V. Issues Requiring Further Clarification

1. Additional studies with DMSA are required to determine whether DMSA scanning in acute pyelonephritis can modify outcome and treatment.
2. SPECT can cause false-positive images and reduce interobserver reproducibility.

VI. Concise Bibliography

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VII. Disclaimer

The Society of Nuclear Medicine has written and approved guidelines to promote the cost-effective use of high-quality nuclear medicine procedures. These generic recommendations cannot be applied to all patients in all practice settings. The guidelines should not be deemed inclusive of all proper procedures or exclusive of other procedures reasonably directed to obtaining the same results. The spectrum of patients seen in a specialized practice setting may be quite different from the spectrum of patients seen in a more general practice setting. The appropriateness of a procedure will depend in part on the prevalence of disease in the patient population. In addition, the resources available to care for patients may vary greatly from one medical facility to another. For these reasons, guidelines cannot be rigidly applied.

Advances in medicine occur at a rapid rate. The date of a guideline should always be considered in determining its current applicability.