

# Procedure Guideline for Renal Cortical Scintigraphy in Children

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## PART 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.

## PART 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 four times as many defects as intravenous urography (1,2). 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 a similar sensitivity and specificity to cortical scanning for the detection of acute pyelonephritis, but adds to the risk of contrast reaction and has a higher radiation exposure (3).

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 nonspecific 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 frequently seen (2,4).

## PART III. COMMON INDICATIONS

- A. Acute pyelonephritis
- B. Renal scarring
- C. Relative functioning renal mass
- D. Solitary or ectopic renal tissue (e.g., pelvic kidney)

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Note: All 26 SNM-approved procedure guidelines are available on the Society's home page. We encourage you to download these documents via the Internet at <http://www.snm.org>. If you would like information on the development process of this guideline or to order a compendium of all 26 procedure guidelines for \$20.00, please contact Wendy J.M. Smith, Society of Nuclear Medicine at (703) 708-9000, ext. 242 or via e-mail at [wsmith@snm.org](mailto:wsmith@snm.org).

- E. Horseshoe and pseudohorseshoe kidneys
- F. Allergy to iodinated contrast agents

## PART IV. PROCEDURE

### A. Patient Preparation

1. Preparation prior to 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 prior to the delayed imaging.
  - b. An informed consent, patient preparation and pre-sedation evaluation are necessary for administration of sedation.
    1. Sedation may have to be administered for the performance of procedures which require the younger child or uncooperative older child to remain motionless for a prolonged period of time.
    2. High-resolution, pin-hole collimation and SPECT require prolonged imaging times (30 min or more) and motion obscures the presence of defects in the cortex of the kidneys.
    3. Details of pediatric sedation can be referenced from *Society of Nuclear Medicine Procedure Guideline for Pediatric Sedation in Nuclear Medicine* and the guidelines published by the American Academy of Pediatrics (5).
2. Preparation prior to injection of the radiopharmaceutical
  - a. The procedure is explained to parents and all children old enough to understand.
  - b. Continual communication and reassurance with explanation of each step is essential for cooperation and successful intravenous injection of the radiopharmaceutical.

### B. Information Pertinent to Performing the Procedure

1. A 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. The review of available past radiographic, ultrasound and radionuclide studies adds to the accuracy of interpretation of the current study.
3. A history to evaluate for allergic reactions and previous complications to sedation.

### C. Precautions

Patients with renal tubular acidosis show reduced tubu-

**Table 1**  
Radiation Dosimetry in Children\*  
(5-yr-old)

Radiopharmaceutical	Administered activity MBq/kg (mCi/kg)	Organ receiving the largest radiation dose <sup>‡</sup> mGy (rad)	Effective dose <sup>‡</sup> mSv (rem)
<sup>99m</sup> Tc-DMSA	1.5–1.9	0.45	0.039
	(0.04–0.05)	kidneys (1.65)	(0.14)
<sup>99m</sup> Tc-GH	3.2–4.2	0.15 <sup>†</sup>	0.024
	(0.08–0.12)	bladder wall (0.56)	(0.089)

\* Treves ST. *Pediatric nuclear medicine*, 2nd ed. New York: Springer-Verlag; 1995:556–571.

<sup>†</sup> ICRP 53, page 194.

<sup>‡</sup> Per MBq (per mCi).

lar concentration of <sup>99m</sup>Tc-DMSA and increased excretion in the urine (6).

#### D. Radiopharmaceutical (Table 1)

1. Technetium-99m-dimercaptosuccinic acid (DMSA) is bound to proximal tubular cells with 40%–65% of the injected dose present in the cortex 2 hr after the injection. The greater amount of activity in the cortex permits better resolution of cortical defects. DMSA is preferred in small infants.
2. Technetium-99m-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 hr 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 hr 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 hr after the injection) may be necessary for quantitation of split renal function when there is a severely obstructed collecting system.
5. The renal cortical exposure to the kidneys is equivalent for both radiopharmaceuticals if there is adherence to the suggested doses. 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 <sup>99m</sup>Tc-DMSA is about 10 MBq (0.3 mCi). The maximum administered activity for <sup>99m</sup>Tc-DMSA is about 110 MBq (3.0 mCi).
8. The minimal administered activity for <sup>99m</sup>Tc-GH is about 20 MBq (0.5 mCi). The maximum administered activity for <sup>99m</sup>Tc-GH is about 300 MBq (8.0 mCi).

#### E. Image Acquisition

1. Posterior and posterior oblique parallel hole high-resolution or ultra high-resolution images of both

kidneys are obtained for 300,000 to 500,000 counts on a 128 × 128 or 256 × 256 matrix format. Analog images are also acceptable.

2. Posterior and posterior oblique pinhole collimation (2–3 mm aperture) imaging with high-resolution collimator magnification of each kidney is obtained for approximately 150,000 counts (15–20 min per image) using a 128 × 128 or 256 × 256 matrix. This allows detection of smaller cortical defects.
  3. Horseshoe and pelvic kidneys are better defined when imaged anteriorly to detect the connecting bridge of renal tissue anterior to the spine.
    - a. In patients who have a history of a high congenital spinal defect (e.g., meningomyelocele) horseshoe and pseudohorseshoe kidneys lie in the deep kyphotic fossa and the examination should then be performed with the patient in the prone or lateral decubitus position.
    - b. In these patients horseshoe and pseudohorseshoe kidneys lie in the deep kyphotic fossa and are better defined on posterior imaging than anterior imaging.
  4. SPECT requires sampling over 360° on a 128 × 128 matrix. A multi-headed camera may reduce the imaging time providing time and counts remain the same (7).
  5. Anterior posterior acquisition for geometric mean.
- #### F. Interventions
1. An indwelling venous catheter may be necessary in the younger children (<4 yr) or in older children 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 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 back pressure 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 prior to the delayed imaging or the patient can return for imaging 24 hr after the injection of the radiopharmaceutical.
- #### G. Processing
- For determination of percent differential function, regions of interest of each kidney and background areas are outlined on the computerized posterior image.
- #### H. Interpretation/Reporting
1. DMSA localization is usually not seen in the medulla or the collecting system.
  2. The position, size and overall morphology of the functioning renal tissue should be noted.
  3. The split function normally varies from 50%/50% to 44%/56% (left kidney/right kidney).
  4. The number, size and location of areas of cortical loss should also be noted.
    - a. Acute pyelonephritis may appear as single or multiple defects.

1. The cortical defect may have reduced or absent localization with indistinct margins that does not deform the renal contour.
2. A localized increase in volume of a single affected area or a diffusely enlarged kidney with multiple defects may occur.
- b. A mature cortical scar may have relatively sharp edges with contraction and reduction of the volume of the affected cortex.
  1. Scarring can manifest as cortical thinning, flattening or an ovoid or wedge shaped defect.
  2. The defect may become more obvious with growth of normal surrounding cortex.
  3. The scan defect related to acute pyelonephritis may resolve in a variable period of time depending on the severity of infection.
- c. Acute and chronic pyelonephritis or scarring cannot always be distinguished on the cortical scan.

#### I. Quality Control

Air introduced into reaction vial can degrade the DMSA complex resulting in decreased renal uptake and increased hepatic and background activity (8).

#### J. Sources of Error

1. The flattening of the superolateral aspect of the left kidney may be attributed to the splenic impression.
2. Multiple irregularities of the cortex may be attributed to fetal lobulations in young children.
3. Immature renal function in newborns may reduce the kidney to background ratio and reduce the detection of renal defects.
4. Children less than one year of age have a smaller percentage of lesions detected than children older than one year of age (9).

### PART V. 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 than 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.

### PART VI. ISSUES REQUIRING FURTHER CLARIFICATION

Additional studies with DMSA are needed to determine the clinical value of planar scintigraphy, pinhole scintigraphy and SPECT in the evaluation of patients suspected of having pyelonephritis (10,11).

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### PART VIII. LAST HOUSE OF DELEGATES APPROVAL DATE

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### PART IX. NEXT ANTICIPATED APPROVAL DATE

1998

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