Dynamic Renal Scan  
(Tc-99m-MAG3)

Radiology Associates of Clearwater  

Overview  

The Renal Tubular Secretion Study images Tc-99m-MAG3 as it passes through the vascular system, renal tubular cells, tubular lumens, and collecting system. This series of images allows the sequential evaluation of renal perfusion, renal clearance by tubular secretion, renal parenchymal transit time, and passage of urine through the renal collecting system. In addition, the study provides high contrast images for evaluation of renal anatomy.

Indications  

Evaluation of renal perfusion and function (1).

Evaluation of renal trauma.

Diagnosis of renovascular hypertension (2).

Detection and evaluation of renal collecting system obstruction (3).

Evaluation of renal transplants.

*Exams ordered for indications which are not listed above need to be discussed with the Nuclear Medicine Physician.

Examination Time  

45 minutes.
120 minutes for an ACE inhibitor study.

Patient Instructions  

Routine Renal Scan  
Patients may take medications and eat before coming in. Unless the patient is on fluid restriction, he/she should drink copiously, at least 16 ounces of water or other fluid, 30-60 minutes before coming to the department.

Do not schedule patient for renal scan after IVP (same day).

Catopril Renal Scan  
The Captopril scan will be performed on Day 1. Length of the exam is 2.5
hours. Some patient studies will be complete the first day. Others will need a second scan two days later (length 2 hours). The Department will need to be able to reach the patient later on Day 1, after processing is complete, and the call tech is to notify patient if it is necessary to return.

For Lasix renal scans discontinue diuretics for 24 hours prior to the exam.

For the captopril study, ACE inhibitors and diuretics should be held for at least 48 hours, if OK with ordering physician.

For return scan only: ACE inhibitors and diuretics must be discontinued at least 48 hours before the test, or results are invalid. Patients may continue all other medications. Check with referring physician to be sure this is not a problem.

<table>
<thead>
<tr>
<th>Trade Name</th>
<th>Generic Name</th>
<th>Discontinue For</th>
</tr>
</thead>
<tbody>
<tr>
<td>All diuretics</td>
<td>Vary</td>
<td>1 day</td>
</tr>
<tr>
<td>Capoten</td>
<td>(Captopril)</td>
<td>2 days</td>
</tr>
<tr>
<td>Capozide</td>
<td>(Captopril)</td>
<td>2 days</td>
</tr>
<tr>
<td>Accupril</td>
<td>(Quinapril)</td>
<td>2 days</td>
</tr>
<tr>
<td>Altace</td>
<td>(Ramipril)</td>
<td>2 days</td>
</tr>
<tr>
<td>Cozaar, Hyzaar</td>
<td>(Losartan)</td>
<td>2 days</td>
</tr>
<tr>
<td>Lotensin</td>
<td>(Benazepril)</td>
<td>2 days</td>
</tr>
<tr>
<td>Monopril</td>
<td>(Fosinopril)</td>
<td>2 days</td>
</tr>
<tr>
<td>Prinivil</td>
<td>(Lisinopril)</td>
<td>2 days</td>
</tr>
<tr>
<td>Vaseretic</td>
<td>(Enalapril)</td>
<td>2 days</td>
</tr>
<tr>
<td>Vasotec</td>
<td>(Enalapril)</td>
<td>2 days</td>
</tr>
<tr>
<td>Zestril</td>
<td>(Lisinopril)</td>
<td>2 days</td>
</tr>
<tr>
<td>Diovan</td>
<td>(Valsartan)</td>
<td>1 day</td>
</tr>
<tr>
<td>Lexxel</td>
<td>(Vasotec &amp; Felodipine)</td>
<td>1 day</td>
</tr>
<tr>
<td>Lotrel</td>
<td>(Lotensin, Norvasc)</td>
<td>1 day</td>
</tr>
<tr>
<td>Mavik</td>
<td>(Trandolapril)</td>
<td>1 day</td>
</tr>
<tr>
<td>Univasc</td>
<td></td>
<td>1 day</td>
</tr>
<tr>
<td>Vaseretic</td>
<td>(Vasotec &amp; HCTZ)</td>
<td>1 day</td>
</tr>
<tr>
<td>Zestoretic</td>
<td>(Zestril &amp; HCTZ)</td>
<td>1 day</td>
</tr>
</tbody>
</table>

Unless the patient is on fluid restriction, he/she should drink 16 ounces of water or other fluid just before coming to the Department.

**Lab / Image Correlation**

Request recent BUN and creatinine or obtain from BEACON, if available.
Patient Preparation

The patient should hydrate by drinking at least 16 oz of water 30-60 minutes prior to the study.

IV hydration will be performed if indicated (NPO, Volume depletion)
- An IV will be started prior to the study and the patient hydrated with 500cc of normal saline (10cc/kg) before radiotracer administration. (Pts > 8 years old).
- **Pediatrics (<=8 years old)** [SNM Guidline for Diuretic Renography in Children 1997]
  - 10-15 ml/kg of D5 0.22% NS for <1 year old.
  - 10-15 ml/kg of D5 0.45% NS for age 1-8 years old

The patient should void before beginning the study.

If the patient has an indwelling catheter draining either the bladder or a nephrotomy, do not clamp unless specifically requested by the Nuclear Medicine physician. Indicate the presence of an indwelling catheter on the hard copy film of the serial static images. Try to move any “reservoir” (Foley bag, or ileostomy bag) from the field of view.

Equipment & Energy Windows

- Gamma camera: Large field of view.
- Collimator: Low energy, high resolution, parallel hole.
- Energy window: 20% window centered at 140 keV.
- Computer.

Radiopharmaceutical, Dose, & Technique of Administration

- Radiopharmaceutical:
  - Tc-99m-mercaptoacetyltriglycine(Tc-99m-MAG3) (4-7).
  - Tc-99m-DTPA

- Dose: 10 mCi (370 MBq).

- Technique of administration: Intravenous.

Patient Position & Imaging Field

- Patient position: Supine.
Imaging field: All of kidneys and bladder.

**Acquisition Protocol** (8,9)

Position the camera under the table for POST images.

Acquire serial 2 sec/frame dynamic images for 60 seconds, 128x128 matrix.

Acquire 15 sec/frame dynamic images for 1740 seconds, 128x128 matrix.

Acquire a posterior post void image at the end of each dynamic phase.

Have the patient void at the end of the study to significantly reduce the gonadal radiation dose (10).

**Data Processing**

**Differential function:**
Place regions of interest around the entire kidney using the ~2 minute image (Before collecting system activity is seen).
Place “C” shaped background regions around each kidney for background subtraction (These regions may be saved for use in the following processes).

**20 minute % of peak parenchymal activity:**

1) Place regions of interest over the cortex of each kidney (excluding the calyces) using the 20 minute image. Place “C” shaped background regions around each kidney for background subtraction.

2) Generate 20 minute renal cortex curves and screen save.

**T/12:**

1) Place regions of interest around the collecting systems of each kidney. Place “C” shaped background regions around each kidney for background subtraction.
2) Set time mark at beginning of lasix administration and generate curves.
3) Screen save the final results.

**Optional Maneuvers**

**Imaging a transplanted kidney:**
1. The patient is positioned supine.
2. Images are acquired in the ANT projection.
3. The field of view includes the transplanted kidney and bladder (usually imaging the entire pelvis will accomplish this).
4. The acquisition and quantification is otherwise the same as for native kidneys.

**Diuretic washout renal study (3, 13-15):**

Follow the routine protocol (Dynamic Renal Scan), with the additional intravenous injection of diuretic 10 minutes after the injection of the radiopharmaceutical, or at maximal filling of the renal collecting systems (this will occur late in renal insufficiency). Have patient void just prior to injection of radionuclide.

Pharmaceutical dose: For all patients - Furosemide (Lasix) 40 mg (or as ordered) is administered intravenously over 1 minute. Pediatrics - 1 mg/kg in infants, 0.5 mg/kg age 1-16 years.

Nuclear Medicine physician may request Foley catheter.

Place regions of interest around the renal pelvis and calyces on each side. (Background subtraction is not essential.)

Normal halftime clearance is approximately 10 minutes; abnormal is over 20 minutes; and between 10 and 20 minutes is often considered indeterminate (3,14,17).

**Angiotensin converting enzyme (ACE) inhibitor renal study (21-26):**

Chronic administration of ACE inhibitors and diuretics may decrease the sensitivity of the test (23):

a. Stop ACE inhibitors and diuretics at least 48hrs prior to the study. Stop all other blood pressure medications the night before the study.

b. The technologist will confirm stopping of blood pressure medications and record a baseline blood pressure. If <140/90 the nuclear medicine physician will be notified to decide if the test should be started.

Proceed to ACE inhibition study.

With the patient supine, administer an ACE inhibitor (23):

- Captopril: 50 mg orally. (Since food in the gastrointestinal tract delays absorption, the patient should fast for 4 hour prior to the study if captopril will be used.)

Record the patient's blood pressure every 15 minutes for 1 hour.
Timing of radiopharmaceutical injection:

- Inject Tc-99m-MAG3 (10mCi) 60 minutes after ingestion of the captopril.

Depending on the results of this test, the Nuclear Medicine physician may ask for the patient to return for a baseline examination (performed without an ACE inhibitor).

Quantitation of renal tubular function in terms of % renal uptake of the injected dose without blood or urine sampling (8,29,30):

1. This approach is valid for adults with normal cardiac output and normal vascular volume.
2. Use a 5 mCi dose of Tc-99m-MAG3 and a low energy, high resolution collimator (8,31).
3. Before injecting the dose obtain a 1 minute count of the syringe with the gamma camera by placing it 30 cm in front of the center of the camera (8,31).
4. Acquire a routine quantitative renal study (see above).
5. Obtain an analog image of the injection site to detect infiltration.
6. Obtain a 1 minute count of the residual radiopharmaceutical in the syringe, again with the syringe 30 cm in front of the center of the camera.
7. Place regions of interest around both kidneys and below both kidneys for background.
8. Determine the counts in the 4 regions of interest from 2 to 3 minutes post injection.
9. Calculate the depth of each kidney based on the patient's height, weight, and age (8,32-34).
10. Calculate the global and fractional right and left renal tubular function using the Renal Tubular Function Worksheet (see below).

**Principle Radiation Emission Data - Tc-99m** (38)

- Physical half-life = 6.01 hours.

<table>
<thead>
<tr>
<th>Radiation</th>
<th>Mean % per disintegration</th>
<th>Mean energy (keV)</th>
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<tbody>
<tr>
<td>Gamma-2</td>
<td>89.07</td>
<td>140.5</td>
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**Dosimetry - Tc-99m-MAG3** (9)

<table>
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<tr>
<th>Organ</th>
<th>rads/10 mCi</th>
<th>mGy/370 MBq</th>
</tr>
</thead>
<tbody>
<tr>
<td>Bladder wall</td>
<td>4.8 hour void 4.8</td>
<td>48.0</td>
</tr>
<tr>
<td>Ovaries</td>
<td>4.8 hour void 0.26</td>
<td>2.6</td>
</tr>
<tr>
<td>Testes</td>
<td>4.8 hour void 0.16</td>
<td>1.6</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>-----</td>
<td>-----</td>
<td>-----</td>
</tr>
<tr>
<td>Kidneys</td>
<td>0.14</td>
<td>1.4</td>
</tr>
<tr>
<td>Total body</td>
<td>0.07</td>
<td>0.7</td>
</tr>
<tr>
<td>Liver</td>
<td>0.04</td>
<td>0.4</td>
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</table>

References


Normal Findings

ENCODING:

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<tr>
<th>Procedure</th>
<th>MPH #</th>
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<tbody>
<tr>
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<td>78707</td>
</tr>
<tr>
<td>Kidney imag-w/pharm interven</td>
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<td>78708</td>
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</table>

JSM
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Note: This protocol is in agreement with the Society of Nuclear Medicine Procedure Guidelines Manual, 1997.
This protocol complies with the Society of Nuclear Medicine Procedure Guidelines for Diagnosis of Renovascular Hypertension, June 20, 2003.
RENAL TUBULAR FUNCTION (% UPTAKE) WORKSHEET
Nuclear Medicine Department

Institution __________________________

Patient name____________________________ ID______________
Date_____________ Weight______(kg) Height______(cm)
Age_____(yr)

NOTE: Many nuclear medicine computers have software that performs one or more
of the steps below automatically.

STEP 1 Calculate the net injected dose from the syringe images:

\[
\text{pre injection (cts) - post injection (cts) = net injected dose (cts)}
\]

\[
\text{__________(cts) - __________(cts) = __________(cts)}
\]

STEP 2 Calculate the renal depth of both kidneys using the method of Taylor:

\[
[151.3 \times \text{weight (kg)} + \text{height (cm)}] + 0.22 \times \text{age (yr)} + 0.77 = \text{right kidney depth (mm)}
\]

\[
[151.3 \times \text{____(kg)} + \text{____(cm)}] + 0.22 \times \text{____(yr)} + 0.77 = \text{____(mm)}
\]

\[
[161.7 \times \text{weight (kg)} + \text{height (cm)}] + 0.27 \times \text{age (yr)} + 0.7 = \text{left kidney depth (mm)}
\]

\[
[161.72 \times \text{____(kg)} + \text{____(cm)}] + 0.27 \times \text{____ (yr)} + 0.7 = \text{____(mm)}
\]

STEP 3 Calculate the percent uptake of the injected dose in each kidney at 2
to 3 minutes using the equation:

\[
\frac{[A-B] \times P \times 100\%}{[e^{\exp(-\mu Y)}] \times D} = U \%
\]

Where:
U = percent uptake (%)
A = counts per pixel right or left kidney (cts/px)
B = counts per pixel corresponding background (cts/px)
P = pixels in kidney region of interest (px)
\[ e = \text{natural log} = 2.718 \text{ (no units)} \]
\[ \mu = \text{attenuation coefficient for Tc-99m} = 0.0153 \text{ (1/mm)} \]
\[ Y = \text{kidney depth (mm)} \]
\[ D = \text{net counts for syringe containing dose (cts)} \]
\[ \exp = \text{exponent} \]

Right kidney:

\[
\frac{[\text{cts/px} - \text{cts/px}] \times \text{(px)} \times 100\%}{[2.718 \exp - 0.153 (1/mm) \times \text{mm}]} \times \text{(cts)} = \text{uptake} \%
\]

Left kidney:

\[
\frac{[\text{cts/px} - \text{cts/px}] \times \text{(px)} \times 100\%}{[2.718 \exp - 0.153 (1/mm) \times \text{mm}]} \times \text{(cts)} = \text{uptake} \%
\]

**STEP 4** Add the percent uptakes of the two kidneys together to obtain the global percent uptake (a measure of renal clearance):

right (\% uptake) + left (\% uptake) = global (\% uptake)

\[
\text{uptake (\% uptake)} + \text{uptake (\% uptake)} = \text{uptake (\% uptake)}
\]

Technologist__________________________
MORTON PLANT
Nuclear Medicine Department

VASOTEC RENAL - WORKSHEET

Name: ____________________________  MR#: ____________________________
Date: ____________________________

1. Give 12-24 oz. water to drink @ ______________
2. IV inserted @ ______________
3. Begin IV of 500 cc NS @ 500 cc/hr @ ______________
4. Foley catheter inserted @ ______________
5. Place patient supine. Baseline HR _______  BP _____________
6. Vasotec calculation: 0.04 mg/kg @ 1.25 mg/cc = _______ cc **max. 2.5 mg (2 cc)**
7. Administer Vasotec IV over 5 min. @ ______________ (30 min. after hydration began).
   (Dilute in NS to total of 50 cc. Set IVAC @ 600 cc/hr.)
   HR _______  BP _____________
8. Lower IVAC rate to 500 cc/hr for remainder of scan (not to exceed 500 cc).
   HR _______  BP _____________  (begin @ ___________).
9. Administer Lasix 5 minutes after Vasotec began (over 2-6 min.)
   Patient Cr = _______ (date _______) Lasix dose = 40mg @ ______________.
10. HR and BP at 5 minute intervals until imaging begins
    Time  HR  BP
          ___________  ___________  ___________
          ___________  ___________  ___________
          ___________  ___________  ___________
11. After scan:
Supine

Sitting

12. Foley catheter removed @ __________ Total output __________ cc

13. If patient is light-headed, do not discharge until seen by physician. Discharged @ __________

14. Patient needs to return ___ Yes ___ No
   (Reminder: do NOT take ACEI or diuretics till after second scan).

15. Notified to return: date __________ @ __________

Signature: __________________________

MORTON PLANT HOSPITAL
Nuclear Medicine Department

RENAL SCAN WITH CAPTOPRIL

Name: ________________________________ A#

Date: ________________________________

Baseline: ___________________ BP _______________ HR __________________

Give 12-24 oz. of water to drink @ __________________

Captopril 50 mg p.o. given @ __________________

IV reseal ______ inserted ____________________________ @

IV of 500 cc NS over 1 hour begun @ __________________

Foley catheter: _______

q 15 min. BP & HR:
5 min. after Captopril  BP __________________  HR __________________

15 min.  BP __________________  HR __________________

30 min.  BP __________________  HR __________________

45 min.  BP __________________  HR __________________

60 min.  BP __________________  HR __________________

Post scan BP & HR:
Supine  BP __________________  HR __________________

Fowlers  BP __________________  HR __________________

Foley cath removed @ ___________  Total output ___________ cc

If patient is light-headed, do not discharge until seen by physician.

Discharged @ __________________

Patient needs to return _____ yes _____ no

(Reminder: do not take ACEI or diuretics for 48 hr prior to second scan.)

Notified to return: date ___________ @ _______________

Signature: ____________________________________________

NOTES