Clinical Protocol: NUCLEAR MEDICINE RENAL FLOW & FUNCTION (Tc-99m-Mercaptoacetyltriglycine Mertiatide, MAG 3)

Date Last Reviewed: 5/30/2024
Responsible Division: Division of Nuclear Medicine, Department of Radiology, UT Southwestern

Policy Basis for Procedure: To establish a protocol for renal flow and function scintigraphy with Tc-99m-Mercaptoacetyltriglycine (Mertiatide, MAG 3)

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

Scope: This policy applies to all individuals working in William P. Clements Jr. University Hospital and all hospital- based clinics, and Parkland Memorial hospital

Indications

- Assess renal perfusion and function, including differential renal function
- Assess urinary tract obstruction
- Assess renovascular hypertension
- Assess renal allograft perfusion, function and complication
- Estimate renal plasma flow (ERPF)
- Distinction between obstructive and non-obstructive hydronephrosis
- Renal transplant evaluation

Contraindications:

- For the pregnant or potentially pregnant mothers, a pregnancy screening form must be administered. Interruption of breastfeeding is not required. The attending physician must be notified of a positive pregnancy test result and will provide instruction on how to proceed.
- Patients who are breastfeeding should be instructed to pump and discard milk for 4 hours after injection
- Diuretics if performing optional maneuver protocol (Renal with Lasix) *see medication table under optional maneuvers*

Examination Time:

- Imaging: 45 – 60 minutes

Patient Preparation:

- No dietary prep
- Unless contraindicated, the patient should be instructed to arrive well hydrated.
- Verify order questions and notes to ensure imaging considerations are followed as requested (upright, transplant, open/clamping of nephrostomy tubes, etc.)
- Instruct the patient to void just prior to the exam to include emptying any supplementary urine collection bags to lower the radiation dose to the skin and bladder.
- Patients who present with concerns for incontinence shall be provided disposable scrubs and attention should be given to prevent contamination of the area and equipment with absorbent padding.

Radiopharmaceutical, Input Injected Activity, and Technique of Administration

- Radiopharmaceutical: Tc-99m-mercaptoacetyltriglycine (Tc-99m-MAG3)
- Dose : (faculty may decrease dose amount among shortages)
    - Adult: 10 mCi, +/- 20%
    - Adult: 5 mCi, +/- 20 for renal transplant evaluation
    - Pediatric : Children with angiographic phase: 0.15 mCi/kg; minimum 1 mCi and Maximum 4 mCi
    - Technique of administration: Intravenous injection utilizing a three way stop cock:
        - Flush 1 cc 0.9% sodium chloride to confirm patent line, bolus the radiopharmaceutical and upon completion, flush with remaining 0.9% sodium chloride

Equipment and Energy Windows

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

Patient position and Imaging field of view

- Patient position: Supine with posterior imaging.
- An upright imaging position may be indicated for patients with a concern for nephroptosis (floating kidney).
- Image in the anterior position for a transplanted kidney (transplanted kidney is typically in the lower abdomen, use a pre-syringe for anatomic location)
- If the patient has nephrostomy tubes, ensure clarification is made as to clamping or leaving open. If the referring instructs to clamp the tubing, do so closest to the body using gauze wrapped around the hemostats as not to puncture the tubing.
- Imaging field: Kidneys and bladder

Acquisition Protocol

- This exam is a continuous acquisition, therefore, repositioning after beginning is not an option.
- Have patients empty their bladder and remove any metal objects before image acquisition.
- Technologists may use a pre-syringe dose (350 uCi – 500 uCi) for positioning purposes
- Ensure proper start of acquisition to capture the bolus into the aorta for accurate data processing. If bolus was missed due to technical issues, a note should be inputted for the reading physician to be made aware.
- Any nonstandard position of the patient and any other deviation from the standard protocol (e.g., extravasation, movement of the patient, premature termination of the scan) should be noted in patient's EMR.
- The acquisition time/counts will need to be increased for any patient receiving a decreased amount of radiopharmaceutical (due to shortages) to provide faculty/residents with optimal quality images required for proper interpretations.

- Acquire dynamic imaging as follows:
    - Flow: 2 seconds/frame for 30 frames, 64 x 64 matrix
    - Dynamic : 15 seconds/frame for 16 frames, 128 x 128 matrix
    - Dynamic : 30 seconds/frame for 81 frames, 128 x 128 matrix
- At the end of the exam, instruct the patient to empty their bladder then acquire a one minute image of the kidneys and bladder labeled post void.

Data Processing

- Utilizing the Xeleris processing workstation, select the renal analysis program and follow the step by step instructions to produce time activity curves for perfusion, function, kidney's, cortex's, and collecting systems.
- All screen captured images should have the radiopharmaceutical information, Lasix dose/minutes post injection, technologist initials, and route of injection
- Send raw files and processed images to Sectra PACS, verify

Optional Maneuvers

- Diuretic washout renal study (**Renal Scan With Lasix**)
    - Hydrate the patient
        - Oral fluids: unless contraindicated, patient should be instructed to be well hydrated prior to the study
    - Perform the routine Tc-99m-MAG3 renal study with digital acquisition for quantitation.
        - Ensure the patient does not have any allergies to Lasix (furosemide)
        - If the patient takes a diuretic as part of their normal medication routine, they should be instructed to withhold their diuretic the morning of their exam. *See table below*
        - Obtain a baseline blood pressure and post exam BP to access for any change in patient's condition; document values into exam notes. *If elevated advise faculty/resident and proceed as instructed (elevated blood pressure definition : Systolic > 190 mmHg , Diastolic > 110 mmHg)
        - At 20 minutes post radiopharmaceutical injection for an adult patient, inject 40 mg of furosemide intravenously over 1 minute
            - Nuclear medicine physician/resident may consider increasing furosemide dose to 80 mg for patients with severely compromised renal function or edema.
        - Consult the radiologist for pediatric dose or renal transplant patient dose.
        - Continue acquiring images for an additional 25 minutes
        - Have the patient void immediately after acquisition is complete and acquire a 1 minute post void image of the kidneys and bladder
        - Utilizing the Xeleris processing workstation, select the Renal analysis program and follow the step by step instructions to produce time activity curves for perfusion, function, kidney's, cortex's, and collecting systems.
        - Normal halftime clearance is approximately 10 minutes; abnormal is over 20 minutes; and between 10 and 20 minutes is often considered indeterminate

Withdrawal of prescribed diuretics on morning of examination	Thiazides: hydrochlorothiazide, indapamide, metolazone, chlorthalidone
	Loop diuretics: furosemide, bumetanide, torsemide, ethacrynic acid

	Potassium sparing: amiloride, spironolactone, triamterene, eplerenone
	Carbonic anhydrase inhibitors: acetazolamide

- Angiotensin converting enzyme (ACE) inhibitor renal study
  - Interfering medications:
    - ACE inhibitors and diuretics may decrease the accuracy of the test. (Discontinue for 2-3 days.)
    - discontinue calcium antagonists
    - angiotensin II receptor antagonists may be continued
  - With the patient supine, administer an ACE inhibitor
    - Enalaprilat: 0.04 mg/kg intravenously infused over 5 minutes. (Enalaprilat has a higher incidence of hypotension so an intravenous line with normal saline is suggested.)
    - 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:
      - Enalaprilat: Inject Tc-99m-MAG3 10 minutes from the end of the enalaprilat infusion.
    - Captopril: Inject Tc-99m-MAG3 60 minutes after ingestion of the captopril.
    - If the ACE inhibitor renal study is abnormal, a baseline Tc-99m-MAG3 renal study should be performed later when the patient has been off ACE inhibitors for at least 2 days

  - Imaging patient in upright position.
    - Patient is placed in the upright position seated on stool with back up against camera head.
    - Images are acquired in the POST projection.
    - The field of view includes kidneys and bladder.
    - The acquisition and quantification is otherwise the same as for native kidneys.
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  - To calculate GFR - calculate residue in syringe

  - Other radiopharmaceuticals may be substituted if or when Tc99m-MAG3 becomes unavailable, including Tc99m DTPA. Use the same acquisition protocols

Principle Radiation Emission Data

- Physical half-life = 6.01 hours
- Radiation : Gamma 2
- Mean % per disintegration : 89.07
- Mean energy (keV): 140.5

Dosimetry

- According to models recommended in ICRP 128, a 370 MBq injection for a Tc-99m MAG3 study would impart to an Adult (gender average) an approximate effective dose of **2.6 mSv** (**0.26 rem**). The critical organ for this study is the bladder, which would receive 40.7 mGy (4.07 rad).

Definitions

- N/A

Applicable Forms

- Pregnancy screening form, if applicable

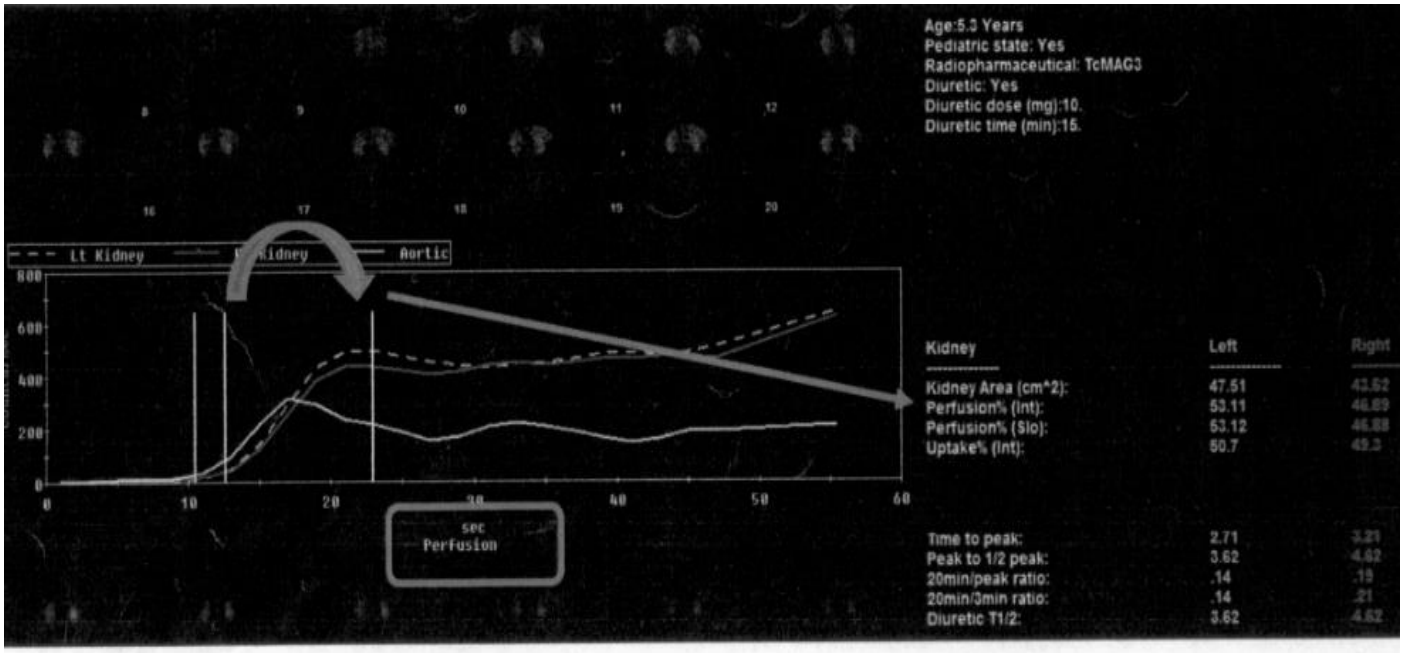
References:

1. ACR-SPR Practice Parameter for the Performance of Renal Scintigraphy (Revised 2017).
2. Society of Nuclear Medicine procedure guideline for diagnosis of Renovascular Hypterension.Version3.0,June20,2003.
3. Breast milk excretion of radiopharmaceuticals: mechanisms, findings, and radiation dosimetry.
4. Stabin MG, Breitz HB J Nucl Med. 2000 May; 41(5):863-73. Radiation dose to patients from radiopharamceuticals. Addendum 3 to ICRP Publication 53. ICRP publication 106. Ann ICRP. 2008; 38(1-2):1-197
5. SNMMI Procedure Standard/EANM Practice Guideline for Diuretic Renal Scintigraphy in Adults With Suspected Upper Urinary Tract Obstruction 1.0. Semin Nucl Med. 2018 Jul; 48(4): 377–390.
6. Package Insert Mag3 : https://dailymed.nlm.nih.gov/dailymed/fda/fdaDrugXsl.cfm?setid=0571c18b-1d5e-47bd-bddf-54d74ce1b442&type=display
7. ACR–ACNM–SPR PRACTICE PARAMETER FOR THE PERFORMANCE OF
8. RENAL SCINTIGRAPHY https://www.acr.org/-/media/ACR/Files/Practice-Parameters/RenalScint.pdf (2022)
9. Diuretic Renal Scintigraphy Protocol Considerations | Journal of Nuclear Medicine Technology (snmjournals.org) (2022)
10. Duration of Breastfeeding Interruption in Nuclear Medicine Procedures (2023)

Review Date	Status	Name and Title	Approver; Date	Brief Summary
5/30/2024	**Submitted**	Orhan Oz, MD, PHD, Daniel Lee, MD; Trizzy Bui, Tech Sup (UT); Julie Eberting (PHHS)	Dr. Orhan Oz, MD, PhD; 11/5/2024	Formatting changes; Amendment to acquisition protocol to remove pre-syringe and injection images, pre-syringe max dose to 500 uCi, acquisition protocol and optional maneuvers
8/2022	**Approved**	Brooke Pipes, Tech Sup	8/2022	Pre syringe dose for renal reference image amended.
7/2021	**Approved**	Brooke Pipes, Tech Sup	7/2021	Addition of Xeleris references
11/2019	**Approved**	Brooke Pipes, Tech Sup	11/2019	Overview modified, administration technique

				standardization
11/2018	**Approved**	Brooke Pipes, Tech Sup	11/2018	45 minute exam
11/2017	**Approved**	Brooke Pipes, Tech Sup	Rathan Subramaniam, 11/2017	Formatting changes

Xeleris Processing



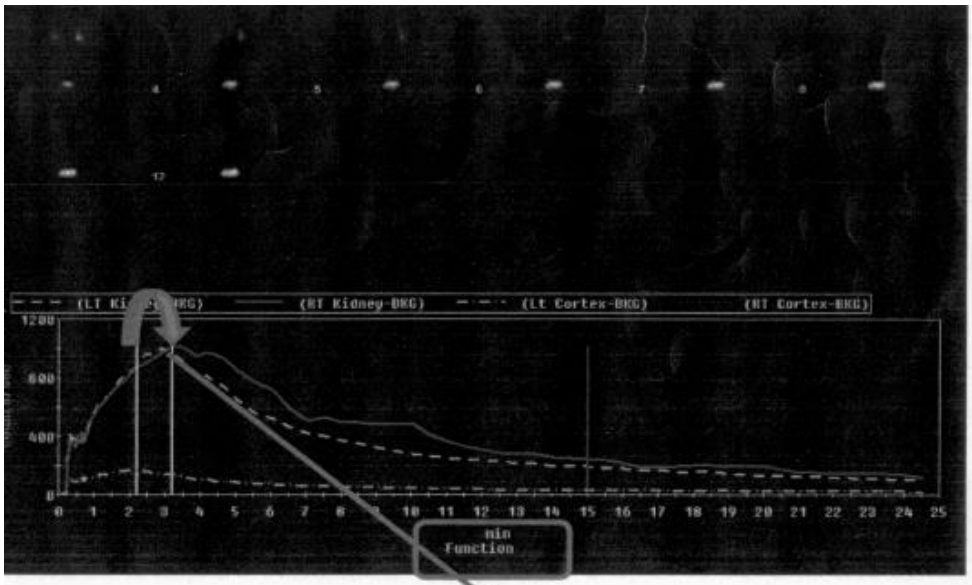
Perfusion %

Relative perfusion of each kidney over the perfusion phase is reported as Perfusion %
Integral – (Int) area under time activity curve
Slope – (Slo) steepness of the curve or "rise over the run"

1. First Yellow cursor represents time when counts are detected in aortic ROI
2. Second Yellow cursor represents time when counts are observed in either kidney region of interest
3. Perfusion % is calculated from the time between second and third yellow cursors.

The relative perfusion values are calculated using two methods: integral and slope. Normally these two values are similar, however error in slope can be due to poor counting statistics and error in integral can be due to inaccurate background subtraction. Typically, integral is most commonly used.

In Parameter customization, reporting of Perfusion % Slope method can be turned off if desired.
Under General Settings>>>Include mean slope method for relative perfusion: No

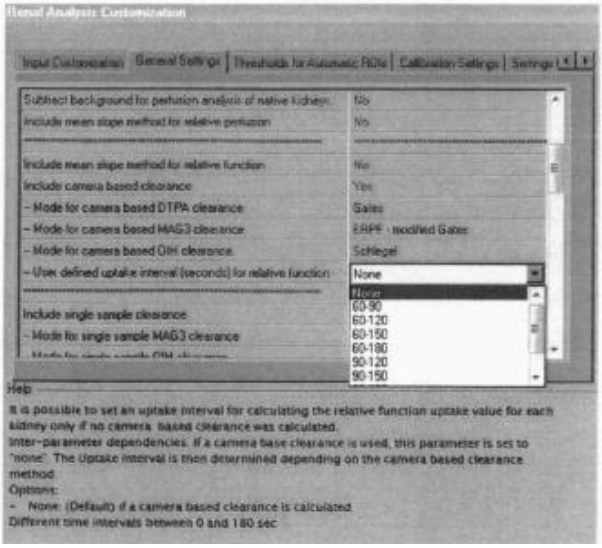


Uptake %

Measurement of the extraction of the agent from blood to kidneys. Ideally uptake is measured prior to excretion of the agent and when agent is most concentrated or at peak. This normally occurs between 2-3 minutes post injection. **Relative Uptake is also known as differential renal function, split renal function or total renal function.**

Kidney	Left	Right
Kidney Area (cm^2):	47.51	43.62
Perfusion% (Int):	53.11	46.89
Perfusion% (Slo):	53.12	46.88
Uptake% (Int):	50.7	49.3

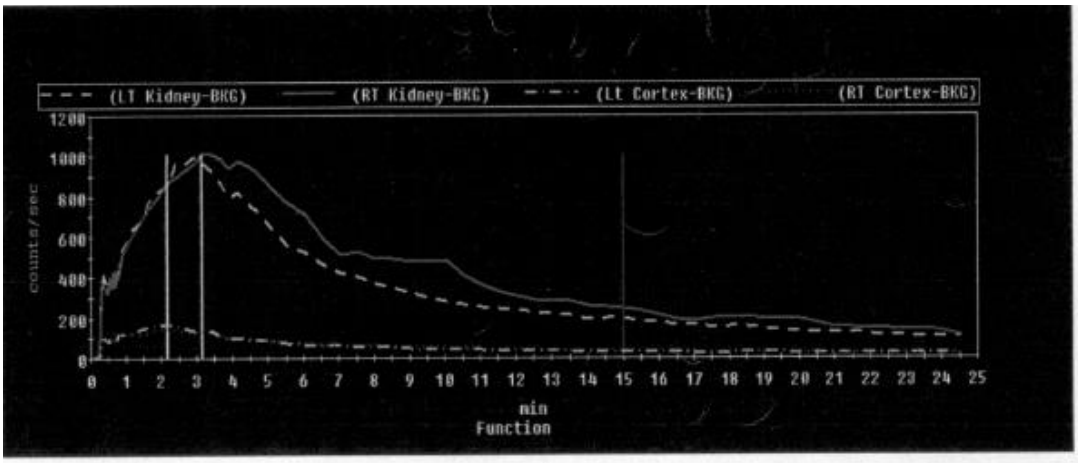
Uptake time is customizable provided that camera-based clearance method is set to none.



Uptake

Uptake is displayed on the function curve between 2-3 min in yellow cursors. This value compares the counts under the left and right curves for this time period and provides a percentage left and right. Uptake% is calculated by two methods: integral and slope. The default is integral. Slope may be turned on in customization if desired.

Uptake time is customizable under General Settings, provided that the camera-based clearance method is set to none.



Calculated values for each curve:
Time to peak – from acquisition start
Peak to ½ peak – from peak time
If diuretic is given, enter dosage and time administered in the study dialogue.

Time to peak:	**9.12**	2.87
Peak to 1/2 peak:	**14.24**	7.
20min/peak ratio:	**.61**	.22
20min/3min ratio:	**.74**	.23
Diuretic T1/2:	**11.49**	12.32

20min/peak ratio – the ratio between the average activity of the curves at 19 to 20 minutes and the peak activity.

20min/3min ratio – the ratio between the average activity of the curves at 19 to 20 minutes and the 3rd minute.

Diuretic T1/2 – the time that elapsed between the administration of the diuretic and the diuretic T1/2.

Note: By default, the diuretic half time will be set to equal Peak to half peak in the following circumstances:

When the diuretic was given before start of acquisition or before peak of renogram.

When the Peak to half peak is less than the half time from diuretic response. Thus when values are equal, the diuretic half time is actually equal or greater than the Peak to half peak.

The diuretic half time will be set to NA if the renogram is upsloping.

When diuretic half time is less than Peak to half peak, it will be displayed as is.

It is possible to change the default for the diuretic half time display to display diuretic half time always or display NA in one of the two circumstances above.

This can be changed in customization of Renal Analysis under the tab Settings for Diuretic Renogram.