Measurement of Glomerular Filtration Rate

**Primary Indications:** Measurement of glomerular filtration rate (GFR) by radionuclide tracer methods is indicated when more precise information than that provided by the measurement of creatinine clearance is required or when the latter measurement is impractical (infants and small children, incontinent patients) or likely to be unreliable (because of marked impairment of renal function or because the patient is taking medications known to interfere with the tubular secretion of creatinine).

**Rationale:** GFR can be calculated by modeling the blood clearance of Tc-99m DTPA or I-125 iothalamate as the sum of two mono-exponential curves. The rapid component of the bi-exponential curve is due to rapid dilution of the tracer in the intra- and extravascular space. The slow component of the clearance curve is due to glomerular filtration. Because of some protein binding of Tc-99m DTPA in plasma, its clearance is approximately 5% lower than that measured with inulin. Also because the plasma clearance curve is used rather than the urine concentration and timed urine volume (the UV/P method), GFRs tend to be overestimated when they are low as a result of clearance of the tracer through other organs (e.g., liver).

**Interfering Conditions:** Dehydration.

**Contraindications:** None

**Precautions:** None

**Radiopharmaceutical: Option 1:** Tc-99m Pentetate (Tc-99m DTPA). For measurement of GFR, the radiopharmaceutical must be freshly prepared (within 3 hours of use).

**Option 2:** I-125 iothalamate.

**Adult Dosage: Option 1:** Tc-99m DTPA
1.0 mCi. in 10 mL of saline solution for GFR measurement only
15 mCi in 10 mL of saline solution for combined GFR measurement and renal scintigraphy

**Option 2:** I-125 iothalamate.
80 µCi in 10 mL of saline.

**Pediatric Dosage: Option 1:** Tc-99m DTPA
10 µCi/kg (minimum 0.1 mCi; maximum 1.0 mCi) in 10 mL of saline solution for GFR measurement only

200 µCi/kg (minimum 2.0 mCi; maximum 15 mCi) in 10 mL of saline solution for combined GFR measurement and renal scintigraphy

Option 2: I-125 iothalamate.
1 µCi/kg (minimum 10 µCi) in up to 10 mL of saline.

Pharm. Drug Dosage: Adult SSKI Dosage: 6 drops (0.3 mL) diluted in 5-10 mL water (provides 130 mg potassium iodide ≈ 100 mg iodide ion).

Pediatric SSKI Dosage:

<table>
<thead>
<tr>
<th>Age</th>
<th>Dosage</th>
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<tbody>
<tr>
<td>&lt;1 month</td>
<td>1 drop p.o. 10 minutes prior to injection of I-123 iothalamate, and again after completion of the 24-hour imaging</td>
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<tr>
<td>1 month to 3 years</td>
<td>2 drops p.o. 10 minutes prior to injection of I-123 iothalamate, and again after completion of the 24-hour imaging</td>
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<tr>
<td>3 to 18 years</td>
<td>3 drops p.o. 10 minutes prior to injection of I-123 iothalamate, and again after completion of the 24-hour imaging</td>
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<tr>
<td>≥ 70 kg to adult</td>
<td>6 drop(s) given 10 minutes prior to injection of I-123 iothalamate, and again after completion of the 24-hour imaging.</td>
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Radiation Dosimetry: Adult.

Option 1: Tc-99m DTPA (1 mCi)

For GFR Measurement Only (see Renal Scintigraphy for Radiation dosimetry with an imaging dosage):


Option 2: I-125 iothalamate (80 µCi).

Critical organ (bladder wall): 36 mrem. Effective dose: 3 mrem.

Infant (1-year).

Option 1: Tc-99m DTPA (0.1 mCi)

For GFR Measurement Only (see Renal Scintigraphy for Radiation dosimetry with an imaging dosage):

**Option 2:** I-125 iothalamate (10 µCi).


(Dosimetry is altered in the setting of impaired renal function. For example, in renal failure, gastrointestinal tract doses are increased, although effective dose is slightly decreased. With acute unilateral obstruction, the dose to the obstructed kidney is substantially increased.)

**Route of Administration:** Intravenous (with use of a quantitative injection technique)

**Pharmacologic Drug:** Saturated solution of potassium iodide (SSKI)

**Pharm. Drug Dose:** Adult: 6 drops (0.3 mL) diluted in 5-10 mL water (provides 130 mg potassium iodide $\approx$ 100 mg iodide ion)  
Pediatric: 1 drop per 12 kg body weight (minimum dose 1 drop) diluted in 5-10 mL water

**Pharm. Drug Route:** Oral

**Patient Scheduling:** Telephone scheduling requests should be directed to the scheduling desk.

**Patient Preparation:** The patient should be well hydrated for the examination.

**Procedure:** 1. Administer SSKI at least 10 minutes prior to the injection of I-125 iothalamate.

2. Adhere to “Policy for Specimen Labels” while preparing samples.

3. Two intravenous access sites are needed, one for injecting the radiopharmaceutical and another for obtaining blood samples. Blood samples cannot be obtained through the same catheter that is used to inject the radiopharmaceutical. 20- to 22-gauge Angiocath catheters should be used and one should be secured with tape.

4. A baseline blood sample should be obtained (Sample #0) and the time of the blood sample should be recorded on the attached GFR data sheet along with the blood drawer’s initials.

5. The weight and activity of the full-dose syringe and time of the assay should be recorded on the attached GFR data sheet along with the technologist’s initials.

6. Approximately 1/20 (between 3 to 10 uCi [usually 0.5 mL]) of the volume in the full-dose syringe should be injected into a volumetric flask (250 mL) for use as a standard. The weight and activity of the dose syringe minus the standard, and time of the assay should be recorded on the attached GFR data sheet along with the technologist’s initials.

7. **A quantitative bolus injection** (see procedure on measurement of blood volume) should be
performed. The time of the injection should be recorded on the attached GFR data sheet. The weight and activity of the empty dose syringe and time of the assay should be recorded on the attached GFR data sheet along with the technologist’s initials.

8. When blood samples are drawn through the catheter, a 1.5- to 2-mL sample of blood should first be drawn to clear the catheter of its contents. This syringe should be discarded. A second syringe should then be used to obtain the blood sample. The blood samples should be injected into mint-green 6-mL gel-separator tubes that contain lithium heparin that are already labeled with the patient name, date of birth and date of study.

9. Blood samples (3 mL) should be obtained at 5, 15, 30, 60, 90, 120, 180, and 240 minutes after the bolus injection of the radiopharmaceutical. The planned time and actual time (to the nearest minute) of each blood sample should be recorded on the GFR data sheet. **Although it is important to draw the blood samples at the planned time, it is more important to record the actual time of the sample accurately.** Use the same clock to determine all actual times.

10. Following the withdrawal of each blood sample, the catheter should be flushed with 2.0 mL of saline.

11. The tubes containing the blood should be spun at full speed (centrifuge setting = 10) for 5 minutes. **Duplicate samples** of exactly 0.3 mL of plasma should be pipetted into well counting tubes.

12. Place the tubes in a well counter cassette in the following order - Tube 0A, 0B, 1A, 1B, 2A, 2B, 3A, 3B, 4A, 4B, 5A, 5B, 6A, 6B, 7A, 7B, 8A, 8B, standard A, standard B, air.

13. For Tc-99m-DTPA, attach well counter protocol clip number 4 (TCGFR) to the cassette. For I-25 iothalamate, attach well counter protocol clip number 6, 18 or 25 (IGFR) to the cassette. Place the cassette in the well counter and start the well counter.

14. If GFR measurement is done in conjunction with Tc-99m DTPA renal scintigraphy, counting should be delayed for 24 hours or until the count rate is below 200,000 counts per minute (<1,000,000 in 5 minutes) for tubes 1A and 1B.

15. Staple the well counter results to the GFR data sheet.

16. Enter the data in the GFR spreadsheet on one of the Mallinckrodt Institute of Radiology (MIR) PCs.. Make sure to use the correct Excel workbook (either "DTPA GFR Template (9198).xls" or "iothalamate GFR Template 080219.xls") located in the MIR common drive G:\nuemcd\In Vitro Clinical folder. These spreadsheets are protected and cannot be changed without saving under another filename.

17. The data entry blocks have been highlighted in the spreadsheets. The non-highlighted blocks
are locked and cannot be changed. See items 1-4. on the attached sample GFR spreadsheet.

18. By default, the spreadsheet uses the last four points to determine the slow component of the clearance curve and uses the first four points to determine the fast component. The data points used for the best fit can be changed by selecting the two-cell array that contains the results of the linear regression. See item 5 on the attached sample GFR spreadsheet.

19. An example of the raw data and the fitted curves is shown on the attached sample GFR spreadsheet.

20. The calculated absolute and normalized GFR (mL/min/1.73 m2) can be found in cells L46 and L47. The height and weight in cm and kg are in cells B10 and B11. The body surface area (BSA) is in cell L45. See 6. of the attached spreadsheet.

21. The well counter printout, completed GFR Data sheet, and the spreadsheet printout should be attached to the requisition and brought to the reading room.

22. For I-125 iothalamate, specimens will be analyzed and results reported within 2 working days. For Tc-99m DTPA, specimens will be analyzed on the day they are obtained and results reported within 1 working day.

**Items Required For Complete Study:**

1. Completed GFR Data sheet along with well counter printout.

2. Completed GFR spreadsheet.

**Review and Approval Date**

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<thead>
<tr>
<th>Signed:</th>
<th>Medical Director</th>
<th>Tech Director/Supervisor</th>
<th>Radiopharm/Rad Saf/Physics</th>
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<tbody>
<tr>
<td>Date:</td>
<td>Revised: 10/14</td>
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