Adrenal Medulla: Pheochromocytoma Scan (mIBG)

RADIOPHARMACY

Radionuclide
- $^{123}$I: $t_{1/2}$: 13.1 hours
  Energies: 159 keV
  Type: EC, $\gamma$, accelerator
- or: $^{131}$I: $t_{1/2}$: 8.1 days
  Energies: 364 keV
  Type: $\beta$, $\gamma$, fission product

Radiopharmaceutical
- $^{123}$I- or $^{131}$I-mIBG (meta-iodobenzylguanidine).
  Available from the University of Michigan Nuclear Pharmacy under an Investigational New Drug (IND) application.

Localization
- Blood flow, guanethidine analog absorbed much the same as norepinephrine into the chromaffin cells of the adrenergic tissue and stored in adrenergic granules.

Quality Control
- $^{123}$I- and $^{131}$I-mIBG > 90%

Adult Dose Range
- $^{131}$I: 500 µCi (18.5 MBq), 1 mCi (37 MBq) for suspected metastatic pheochromocytoma
- $^{123}$I: 3–10 mCi (111–370 MBq)

Method of Administration
- Intravenous injected slowly over 5 minutes if possible.

INDICATIONS
- Detection and localization of benign and malignant intra-adrenal and extra-adrenal pheochromocytomas (usually benign chromaffin cell tumors of the sympathoadrenal system that produce and
secrete catecholamines, e.g., norepinephrine and epinephrine, producing hypertension and ortho-
static [standing] hypotension). These occur within the adrenal medulla and are frequently associated
with hereditary multiple endocrine neoplasia (MEN) types 2A and 2B, neurofibromatosis, von
Hippel-Lindau disease, Carney's triad, and familial pheochromocytoma.

• Localization of site(s) of hormonal overproduction.
• Detection and localization of neuroectodermal (nerve tissue) tumors.
• Detection and localization of neuroblastomas (malignant hemorrhagic tumors of cells resembling
neuroblasts of the sympathetic system, especially the adrenal medulla, and usually occurring in
childhood).
• Detection and localization of other neuroendocrine tumors that share the property of amine
precursor uptake in decarboxylation (APUD), such as:
  • Carcinoid (argentaffin cells of the intestinal tract, bile ducts, pancreas, bronchus, or ovary that
secrete serotonin) tumors
  • Medullary thyroid tumors
  • Parangliomas (tumors of the adrenal medulla, chromaffin cells, and the paranglia)
  • Merkel cell skin tumors
  • Chemodectomas (tumors of the chemoreceptor system)
  • Small cell lung carcinoma
  • Schwannoma
• Evaluation of myocardial norepinephrine receptors.
• Distinguishing neuroendocrine tumors from nonneuroendocrine tumors.
• Detection and localization of metastatic deposits from previously diagnosed pheochromocytoma.
• Staging of the disease.
• Evaluation of chemotherapy and to exclude sub-clinical relapse in bone marrow or bone pain.
• Evaluation of surgery.

CONTRAINDICATIONS

• Allergy to iodine may be a consideration, although doses are small.
• Patient taking interfering medications.

PATIENT PREPARATION

Before Day of Injection

• Physician instructs the patient to take SSKI (saturated solution potassium iodide) or Lugol’s solu-
tion to block free iodine uptake in thyroid. This is administered 1 drop, t.i.d., beginning the day
before radiotracer administration and continuing for 6 days after injection. If there is an allergy to
iodine, perchlorate may be used.
• Physician instructs the patient to take bisacodyl (e.g., Dulcolax®) 10 mg PO, b.i.d. × 3 days before
imaging, to reduce bowel activity. Patient may be required to take laxatives and/or enemas on
afternoons before imaging days; check with radiologist.
• Physician instructs patients with atopic history (genetic disposition to hypersensitivity or allergy to
medications such as iodine or steroids) to be treated with oral antihistamine (e.g., Benadryl® 50 mg)
1 hour before injection of radiotracer.

Days of Injection

• Identify the patient. Verify doctor’s order. Explain the procedure.
• Obtain signed consent from patient and a prescription for the iodine.
• Ensure that the patient is not taking the following drugs: steroids, antihypertensives, reserpine,
tricyclic antidepressants, sympathomimetics (adrenergic, stimulates release of epinephrine),
diuretics as per physician’s order. Ideally, no medications for 2–3 weeks before the examination
(see Drugs to Withhold).
Chapter 2 — Adrenal Medulla: Pheochromocytoma Scan (mIBG)

EQUIPMENT

Camera
- Large field of view

Collimator
- $^{131}$I: Medium energy, general purpose, or medium energy, high resolution
- $^{123}$I: Low energy, all purpose, or low energy, high resolution

Computer Set-up

Statics
- $^{131}$I: 100,000 counts or up to 20 min/image
- $^{123}$I: 500,000 counts or time

Whole Body
- 5–10 cm/min, image at least head to pelvis

Single Photon Emission Computed Tomography (SPECT)
- 360°, 64 stops at 20 sec/stop

PROCEDURE (TIME: ~30–60 MIN/SESSION)

- Ensure patient is off medications and has taken thyroid blocker the night before.
- Instruct patient to empty bladder.
- Place patient in supine position.

$^{131}$I-mIBG: Images at 24, 48, and possibly 72 Hours
- Acquire anterior/posterior images of head/neck, thorax, abdomen, and pelvis.
- Set whole body sweep slow (10 cm/min or less).
- Acquire static images of areas of interest if preferred or protocol. Statics should run at least 100,000 counts or 5–20 minutes.
- Acquire lateral views of abnormal uptake to aid in localization.
- Acquire marker images if protocol (on axillae, lower ribs, and iliac crests). Use 5 µCi $^{131}$I capsule or perhaps store injection syringe for markers until imaging is done.
- Acquire SPECT images if protocol or requested.

$^{123}$I-mIBG: Images at 24, 40 Hours and possibly 72 hours
- Same imaging procedures as above.
- Acquire statics of at least 500 k counts or 15 minutes each.
- Statics should at least include chest, posterior mid-thorax, kidneys centered, and lumbar.
- Whole body sweep at 10 cm/minute or less, anterior/posterior, head to pelvis.
- SPECT images at 45 to 60 seconds/stop.

NORMAL RESULTS

- Uptake occurs in the pituitary, salivary glands, thyroid, liver, and spleen.
- The gallbladder will be visualized in patients with renal failure.
- The kidneys and bladder will visualize because of the renal excretion.
- The heart is visualized in patients with normal catecholamine levels.
- Diffuse lung activity, nasal, neck muscle, and bowel activity may present in some patients.
- The normal adrenal medulla seldom visualizes (30% to 40% on delayed images) and is of low intensity.
- The heart and adrenal medulla are visualized more clearly with $^{123}$I-mIBG.
- There should be no skeletal uptake.
- Areas of normal uptake diminish in intensity over time.
ABNORMAL RESULTS

- Focal areas of increased activity that increase more over time occur.
- Sporadic, unilateral tumors show focal intense uptake.
- Metastatic disease is visualized in the axial skeleton, heart, lung, mediastinum, lymph nodes, and liver.
- Neuroblastomas may arise in any location of sympathetic nervous system tissue, but most often are visualized as an abdominal mass, metastasizing early to bone and bone marrow.
- Images at 72 hours will provide maximal contrast between foci of activity and background.
- Localizes in pheochromocytoma, neuroblastoma, and also carcinoid, medullary thyroid carcinoma and paraganglioma.

ARTIFACTS

- Attenuating articles in clothing.
- Images not taken for enough counts.
- Aggressive chemotherapy may hinder the visualization of some metastasis.
- False-positive results may be caused by recent surgical sites, x-ray therapy to the lungs, and bleomycin-induced pulmonary changes.
- False-negatives can be due to lesions too close to large primary or metastatic mass, or tissue with high normal uptake. No or low tumor uptake related to tumor heterogeneity, ischemic necrosis in tumor mass, lack of granules, loss of tumor capacity to absorb tracer, or pharmaceutical inhibition.
- Focal areas of interest usually linger over time and grow in intensity. Limit false-positive results by delayed images (with obliques and laterals).
- Because of the nature of the disease and because they are off medications, patients may be agitated and not lie still.

DRUGS TO WITHHOLD (IDEALLY, NO MEDICATIONS 2–3 WEEKS BEFORE THE EXAMINATION)

For Three Weeks (affect reuptake mechanism presenting with absence of uptake by salivary glands and heart, and may inhibit uptake in pheochromocytoma)
- Tricyclic antidepressants: e.g., reserpine
- Sympathomimetics: e.g., dobutamine, dopamine, norepinephrine

For Two Weeks (affect depletion of storage vesicle)
- Amphetamines
- ACE inhibitors (captopril, enalapril)
- ARBs (irbesartan, valsartan)
- Bretylium tosylate
- Calcium channel blockers (nifedipine, nicardipine, amlodipine)
- Cocaine
- Digoxin
- Fenoterol
- Guanethidine
- Haloperidol
- Imipramine
- Insulin
- Phenothiazine
- Pseudoephedrine (nasal decongestants)
• Phenylpropanolamine (diet-control drugs)
• Phenylephrine (nasal decongestants)
• Salbutamol
• Terbutaline
• Thiothixene
• Xylometazoline

Alpha- and beta-adrenergic blocking drugs will not affect study with the exception of labetalol (affects both reuptake and storage depletion).

**NOTE**

- mIBG is similar to the catecholamine norepinephrine. Epinephrine and norepinephrine are hormones that regulate smooth muscle tone, heart rate and force of contraction, and physiologic responses associated with stress. Pheochromocytomas produce excess amounts of these hormones resulting in hypertension and other symptoms associated with overabundance of catecholamines.
- Renal and skeletal imaging with $^{99m}$Tc agents can be used in conjunction with this test to aid in localization. Their injections can be timed for optimal scan times at the 24- or 48-hour images with two sets of images taken by changing the energy windows to suit the radiotracer.

**PATIENT HISTORY**  *(or use complete patient history in reference section)*

The patient should answer the following questions.

<table>
<thead>
<tr>
<th>Question</th>
<th>Y</th>
<th>N</th>
</tr>
</thead>
<tbody>
<tr>
<td>Do you have a history or family history of cancer?</td>
<td></td>
<td></td>
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<tr>
<td>If so, what type and for how long?</td>
<td></td>
<td></td>
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<tr>
<td>Do you have a history of hypertension or hypotension?</td>
<td></td>
<td></td>
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<tr>
<td>Do you have palpitations?</td>
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<tr>
<td>Have you felt anxiety or apprehension?</td>
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<tr>
<td>Have you experienced excessive diaphoresis (sweating)?</td>
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<td></td>
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<tr>
<td>Do you have headaches?</td>
<td></td>
<td></td>
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<tr>
<td>Have you experienced a flushed face?</td>
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<tr>
<td>Do you experience nausea or vomiting?</td>
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<tr>
<td>Have you experienced tingling of extremities?</td>
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<td></td>
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<tr>
<td>Are you taking oral contraceptives?</td>
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<tr>
<td>Have you had any recent surgery?</td>
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<tr>
<td>If so, where and when?</td>
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</tbody>
</table>

(continued)
NUCLEAR MEDICINE TECHNOLOGY: Procedures and Quick Reference

<table>
<thead>
<tr>
<th>Question</th>
<th>Y</th>
<th>N</th>
</tr>
</thead>
<tbody>
<tr>
<td>Have you had any chemotherapy or radiation therapy?</td>
<td></td>
<td></td>
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<tr>
<td>Are there any recent or planned PET, CT, ultrasonography (US), MRI, or nuclear medicine (NM) scans?</td>
<td>Y</td>
<td>N</td>
</tr>
<tr>
<td>What medications are you taking?</td>
<td></td>
<td></td>
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<tr>
<td>Have you had any recent laboratory reports (with attention to adrenocorticotropic hormone, aldosterone, catecholamines and metabolites, Na, K)?</td>
<td>Y</td>
<td>N</td>
</tr>
<tr>
<td>Female: Are you pregnant or nursing?</td>
<td>Y</td>
<td>N</td>
</tr>
<tr>
<td>Other department-specific questions.</td>
<td></td>
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</tbody>
</table>

**Students**

Explain the relevancy of each of the above patient history questions to this particular scan. Can you think of others that would be helpful for the interpretation of this type of study?

**Suggested Readings**


**Notes**

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