CSF Shunt Scintigraphy

**Primary Indications:** Cerebrospinal (CSF) shunt scintigraphy is performed to determine the patency and function of a CSF shunt system.

**Rationale:** CSF shunts are used in patients with obstructed CSF flow to divert CSF to an alternative site of absorption. The most commonly used shunt in children is a ventriculoperitoneal (VP) shunt; in adults, ventriculoatrial (VA) shunting is more often performed. Ventriculopleural and lumboperitoneal shunts are less commonly encountered.

By injecting a small volume (<0.2 mL usually) of radiopharmaceutical into the shunt appliance (valve, reservoir, or catheter), the flow through the catheter can be determined under relatively unperturbed physiologic conditions. The dispersal of activity at the tip of the distal catheter should be rapid if the distal end of the catheter is not in a loculated space. Typically, the injection is done with the patient in the supine position. If there is no evidence for rapid flow through the catheter when the patient is supine, images can then be obtained in the upright position to determine if an increase in the hydrostatic pressure gradient enhances flow through the CSF shunt. If rapid flow through the shunt is not seen in the upright position, mechanical means (i.e., pumping the reservoir) can be used to further assess patency.

For direct assessment of the patency of the ventricular catheter (e.g., in order to document a "trapped" ventricle), the distal catheter needs to be occluded during injection of the radiopharmaceutical. The decision to fill the ventricular system by a retrograde injection of the radiopharmaceutical should be made by a neurosurgeon who is familiar with the characteristics of the patient’s shunt appliance, and with the specific clinical problem to be addressed.

**Interfering Conditions:** CSF should not be withdrawn from the shunt appliance prior to injecting the radiopharmaceutical, since the withdrawal of CSF may decrease the CSF pressure to a value below the valve-opening pressure and erro-neously give the impression that the shunt catheter is partially obstructed.

**Precautions:** Tc-99m DTPA and Tc-99m pertechnetate are not specifically approved for intrathecal administration, and accordingly meet the pharmacopoeial bacterial endotoxin standard for an intravenously administered drug. Because the CNS is more sensitive to endotoxins, only ≤10% of the volume of a Tc-99m DTPA vial should be injected for this study whenever the radiopharmaceutical is to be (or may be) refluxed into the ventricular system. With Tc-99m pertechnetate, the volume injected should be ≤10% of the volume of the fresh Mo-99/Tc-99m generator eluate; it will generally be much less than this amount, since it is prepared as a dilution of the generator eluate.

Because of the great variety of shunt appliances, the injection of the radiopharmaceutical should be performed by a neurosurgeon, with monitoring of the procedure by a nuclear medicine staff or resident physician.

**Radiopharmaceutical:** Preservative-free Tc-99m Pentetate (Tc-99m DTPA) [Preferred]
Tc-99m Pertechnetate [Alternate (if preservative-free Tc-99m DTPA is not available)]

**Adult Dosage:** For distal catheter evaluation only: 250-750 μCi. The administered volume should be ≤0.2
mL.
For ventricular reflux and distal catheter evaluation: 1.0-1.5 mCi. The administered volume should be ≤ 0.4 mL.

**Pediatric Dosage:** Same as adult dosage

**Radiation Dosimetry: Tc-99m DTPA:**
The following dosimetry assumes that the catheter is patent and that the Tc-99m DTPA is rapidly distributed systemically.

- Adult (750 µCi). Critical organ (bladder wall): 0.17 rem. Effective dose: 0.014 rem.
- Infant (1 yr, 750 µCi). Critical organ (bladder wall): 0.47 rem. Effective dose: 0.044 rem.

**Tc-99m Pertechnetate:**
The following dosimetry assumes that the catheter is patent and that the Tc-99m pertechnetate is rapidly distributed systemically.

- Adult (750 µCi). Critical organ (upper large intestine): 0.16 rem. Effective dose: 0.036 rem.
- Infant (1 yr, 750 µCi). Critical organ (upper large intestine): 1.05 rem. Effective dose: 0.22 rem.

**Route of Administration:** Depending on the goals of the study, the injection can made into be the reservoir (most common), the valve, or the catheter of the shunt appliance. The selection of the site of injection should be made by a neurosurgeon who is familiar with the characteristics of the patient’s shunt appliance.

**Patient Scheduling:** Request for CSF shunt studies should be directed to the attending nuclear medicine physician or a nuclear medicine resident. This individual should obtain the relevant clinical history, obtain the pager number of the neurosurgeon who will be performing the injection, and determine an approximate time for performing the study.

**Patient Preparation:** The skin over the injection site should be shaved (if necessary) and cleansed with appropriate antisectic solutions. The injection should then generally be draped with a sterile drape. This is usually done by the neurosurgeon who performs the injection.

**Equipment Setup:** Gamma camera: LFOV preferred
- Collimator: LEAP collimator
- Energy window: 140 keV with a 20% window

**Patient Positioning:** The initial images are generally obtained with the patient in a supine position. If there is little spontaneous flow through the catheter, the patient may assume an upright position after 15-20 minutes of imaging in the supine position. If little spontaneous flow occurs after the patient has been in the upright
position for 5-10 minutes, the neurosurgeon may elect to pump the shunt appliance.

**Procedure:** A resident or staff physician should be in attendance when this study is performed so that the interpreting physicians will be familiar with the conditions under which the injection was performed and the images were obtained. The injection of the radiopharmaceutical should be made such that flow in the shunt system is disturbed as little as possible; specifically, CSF should not be withdrawn before injection, the syringe containing the radiopharmaceutical should not be flushed with CSF, and the neurosurgeon should avoid putting local pressure at the injection after removal of the needle.

If possible, the injection should be performed with the patient's chest or abdomen viewed by the scintillation camera to allow for observation of very rapid flow if this occurs. Immediately following the injection, a 60-frame (30 seconds per frame) dynamic study is obtained for 30 minutes. Under most circumstances, the patient will be moved during the dynamic acquisition of these images in order to follow the flow of the tracer through the distal catheter. The films should be carefully marked to indicate time post injection, the patient's position, and any interventions, e.g., pumping of the reservoir, that occurred. Additional images will be obtained at the discretion of the nuclear medicine physician.

The residual activity in the syringe should be measured after injection, and the administered activity reported as the difference between the initial activity and the residual activity.

<table>
<thead>
<tr>
<th>View</th>
<th>Digital Acquisition</th>
<th>Film Display (If Applicable)</th>
</tr>
</thead>
<tbody>
<tr>
<td>30 minute dynamic study</td>
<td>60 x 30-sec images, 128 x 128 (preferred) or 64 x 64 matrix word-mode.</td>
<td>To be determined on a case-by-case basis depending on specific circumstances of imaging</td>
</tr>
<tr>
<td>Additional images</td>
<td>Per the attending physician</td>
<td></td>
</tr>
</tbody>
</table>

**Items Required For Complete Study:**

1. Initial 30-minute dynamic study.

2. Additional images as requested by the attending physician.

3. Carefully labeled films that indicate the post-injection time of the images, the position of the patient, and any interventions that occurred.

4. Transfer of all digital images to archival computer.