Cerebral Radionuclide Angiography for the Determination of the Presence or Absence of Effective Cerebral Perfusion ("Brain Death" Study)

**Primary Indications:** Cerebral radionuclide angiography is used to assess cerebral perfusion as an adjunctive test for the determination of brain death in selected patients. Typically, these patients fall into one of three groups: (1) patients who are being considered as possible organ donors; (2) patients whose deaths may have resulted from criminal activity; and (3) patients in whom other conditions make clinical examination and electro-encephalography less reliable (e.g., hypothermia, drug intoxication).

**Rationale:** Four-vessel cerebral arteriography is the definitive test for diagnosing cessation of circulation to the *entire brain*, but it entails significant practical difficulties and risks. Cerebral radionuclide angiography can be done at the patient's bedside with minimal difficulty. The absence of effective cerebral perfusion documented by radionuclide angiography has been associated with a grave prognosis in several studies.

Radionuclide angiography to assess cerebral perfusion is not required by the Harvard Criteria (or by Missouri law) for diagnosis of brain death, but can be used adjunctively. It is possible that a patient may not meet the clinical criteria for brain death (e.g., the patient may not have absence of spontaneous respiration) and yet may have absence of effective cerebral perfusion. The respiratory centers are located in the brainstem and blood flow to the brainstem is not adequately assessed by radionuclide angiography.

**Interfering Conditions:** Open head wounds may preclude use of a scalp tourniquet.

**Precautions:** Because of the serious implications of this study, the patient's clinical assessment for brain death and the results of the radionuclide angiogram should be reviewed by a staff nuclear medicine physician. The interpretation of the images by the staff nuclear medicine physician may be performed either in the hospital or by remote-access viewing of the digital image data. The staff nuclear medicine physician should either (1) immediately prepare and finalize a report in the radiology information system (IDXRad) or (2) write a note directly in the patient's chart describing the study findings AND dictate a report of the study in the usual manner for subsequent transcription and signature. In addition, the staff nuclear medicine physician should notify the requesting physician about the results of the study, and this communication should be documented in the official report (and, if applicable, in the handwritten note in the patient’s chart). In order to facilitate communication with the patient's attending physicians, the handwritten note should also include the staff nuclear medicine physician's pager number.
**Radiopharmaceutical:** Tc-99m Pentetate (Tc-99m DTPA)

If available, a brain perfusion radiopharmaceutical, either Tc-99m Bicisate (Tc-99m ECD) or Tc-99m Exametazime (Tc-99m HMPAO) can also be used for this study at the direction of the attending nuclear medicine physician.

**Adult Dose:** 20 mCi

**Pediatric Dose:** 280 µCi/kg with a minimum dose of 4.0 mCi

**Radiation Dosimetry:**
- Infant (1 year; 4 mCi Tc-99m DTPA). Critical organ (bladder wall): 4.7 rem. Effective dose: 444 mrem.

**Route of Administration:** Intravenous, with careful attention to achieving a good bolus injection. A central venous line should be used for the injection whenever possible.

**Patient Scheduling:** Requests for brain scintigraphy 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 requesting physician, and determine the urgency for this study.

**Patient Preparation:** None

**Equipment Setup:** Camera: Mobile SFOV
- Collimator: diverging for radionuclide angiogram; LEAP for static images
- Energy window: 140 keV with a 20% window

**Patient Positioning:** Supine

**Procedure:** Prior to the injection of the radiopharmaceutical, a narrow vascular pressure cuff should be placed around the patient's head just above the orbital rims and ears. This vascular pressure cuff should be inflated to just above systolic blood pressure. In patients with scalp or head injuries, permission to use the cuff should be obtained first from the nursing staff or physicians caring for the patient. (The vascular pressure cuff is kept in the red supply box for portable studies.)

Injection of the radiopharmaceutical should be made through the largest venous injection site that is accessible (preferably a central venous catheter, if permission to use this catheter is provided by the nursing staff or physicians caring for the patient). The injection should be made as a compact bolus by using the double-syringe technique. The double syringe technique involves the use of a 3-way stopcock. The syringe containing the radiopharmaceutical should be attached to one port of the stopcock. A syringe containing 20 mL of normal saline solution should be
attached to the other port. The male adapter of the stopcock should be attached to the central line. First, inject the radiopharmaceutical into the central line. Then, inject the 20-mL saline bolus (with the radiopharmaceutical bolus at its leading edge) as rapidly as possible.

An anterior cerebral radionuclide angiogram should be obtained by acquiring sequential 1-second images for 90 seconds. The acquisition should begin at the time of the injection.

Following acquisition of the cerebral radionuclide angiogram, the blood pressure cuff should be removed, the collimator should be changed, and immediate static images should be obtained in the anterior and, when-ever possible, in either lateral projection. The anterior image should be acquired for 500,000 total counts and the lateral images should be obtained for the same time.

Additional views may be requested by the attending nuclear medicine physician.

**Interpretation:** The official interpretation of a radionuclide angiogram obtained for the evaluation of potential brain death is to be rendered only by a staff physician of the Division of Nuclear Medicine. Outside of the routine hours of operation of the Division, one of the staff physicians of the Division will be available on call for this purpose. See **Precautions** for details regarding report documentation.

The diagnosis of "No Effective Cerebral Perfusion" is rendered when: (1) the radionuclide angiogram is technically adequate, i.e., it clearly demonstrates transit of the bolus through the common carotid arteries and, if seen, through the branches of the external carotid arteries (the latter may not always be seen because of the effects of the pressure cuff about the head); and (2) the radionuclide angiogram demonstrates no detectable perfusion via the anterior or middle cerebral arteries or through the superior sagittal sinus during the first transit of the radiometric bolus. The immediate static images may demonstrate either no activity or may show activity (usually faint) in the superior sagittal sinus or transverse sinus.

If the radionuclide angiogram is judged by the nuclear medicine physician to be technically inadequate and if the immediate images show no activity in the dural sinuses, a second set of static images should be obtained after a delay of at least 30 minutes from the time of injection. The anterior image should contain 500,000 counts and the subsequent images should be obtained for the same duration. These subsequent images should include the right lateral view, the left lateral view and, if possible, the posterior view. A diagnosis of "No Effective Cerebral Perfusion" is rendered if both the immediate and the delayed images show no activity in the dural sinuses.

An equivocal interpretation ("The scintigraphic findings do not meet the criteria for diagnosis of absent effective cerebral perfusion") is rendered if the radionuclide angiogram is technically inadequate, but either the immediate or delayed images show any dural sinus visualization.

If either Tc-99m bicisate or Tc-99m exametazine is used for the study, the radionuclide angiogram should be interpreted with the same criteria as described above for Tc-99m DTPA.
However, the key finding on immediate static images for the diagnosis of "No Effective Cerebral Per-fusion" is the absence of tracer uptake in the cerebral hemispheres. With these tracers, it also is possible to assess blood flow to the cerebellum.

<table>
<thead>
<tr>
<th>View</th>
<th>Digital Acquisition</th>
<th>Film Display (if possible)</th>
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</thead>
<tbody>
<tr>
<td>Anterior cerebral radionuclide angiogram (obtained with diverging collimator)</td>
<td>90 x 1-sec images, 128 x 128 (preferred) or 64 x 64 matrix word-mode.</td>
<td>90 x 1-sec images (or reformatted as 30 x 3-sec images).</td>
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<tr>
<td>Immediate static images: anterior and (if possible) either lateral projection (obtained with LEAP collimator)</td>
<td>256 X 256 matrix word-mode; the anterior image is acquired for 500K counts. The lateral views are obtained for the same amount of time.</td>
<td>Static images</td>
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**Items Required For Complete Study:**
1. Radionuclide cerebral angiogram.

2. Immediate static images.

3. All digital data transferred to the clinical work station.

4. Films clearly labeled with the patient's name, date, and time of the study.