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ACR PRACTICE GUIDELINE FOR THE PERFORMANCE OF SINGLE-PHOTON EMISSION COMPUTED TOMOGRAPHY (SPECT) BRAIN PERFUSION IMAGING

PREAMBLE

These guidelines are an educational tool designed to assist practitioners in providing appropriate radiologic care for patients. They are not inflexible rules or requirements of practice and are not intended, nor should they be used, to establish a legal standard of care. For these reasons and those set forth below, the American College of Radiology cautions against the use of these guidelines in litigation in which the clinical decisions of a practitioner are called into question.

The ultimate judgment regarding the propriety of any specific procedure or course of action must be made by the physician or medical physicist in light of all the circumstances presented. Thus, an approach that differs from the guidelines, standing alone, does not necessarily imply that the approach was below the standard of care. To the contrary, a conscientious practitioner may responsibly adopt a course of action different from that set forth in the guidelines when, in the reasonable judgment of the practitioner, such course of action is indicated by the condition of the patient, limitations on available resources or advances in knowledge or technology subsequent to publication of the guidelines. However, a practitioner who employs an approach substantially different from these guidelines is advised to document in the patient record information sufficient to explain the approach taken.

The practice of medicine involves not only the science, but also the art of dealing with the prevention, diagnosis, alleviation and treatment of disease. The variety and

complexity of human conditions make it impossible to always reach the most appropriate diagnosis or to predict with certainty a particular response to treatment. It should be recognized; therefore, that adherence to these guidelines will not assure an accurate diagnosis or a successful outcome. All that should be expected is that the practitioner will follow a reasonable course of action based on current knowledge, available resources, and the needs of the patient to deliver effective and safe medical care. The sole purpose of these guidelines is to assist practitioners in achieving this objective.

I. INTRODUCTION

Single-photon emission computed tomography (SPECT) brain perfusion imaging using lipophilic radiopharmaceuticals that cross the normal blood brain barrier and localize in normal brain tissue is a proven and useful procedure to define the regional distribution of brain perfusion and evaluate a variety of brain abnormalities.

Application of this guideline should be in accordance with the [ACR Technical Standard for Diagnostic Procedures Using Radiopharmaceuticals](#).

For pediatric considerations see Sections V.A.4 and V.B.3.

II. GOAL

The goal of SPECT brain perfusion imaging is to detect abnormalities in regional cerebral perfusion by producing images of diagnostic quality.

III. INDICATIONS

A. Clinical indications for SPECT brain perfusion studies include, but are not limited to:

1. Detecting and evaluating cerebrovascular disease.
2. Differentiating lacunar from nonlacunar infarctions.
3. Predicting the prognosis of patients with a cerebrovascular accident.
4. Evaluating patients with transient ischemic attack.
5. Evaluating patients with suspected dementia.
6. Localizing epileptic foci preoperatively.
7. Evaluating symptomatic traumatic brain injury, especially in the absence of CT and/or MRI findings.
8. Diagnosing encephalitis.
9. Monitoring and assessing vascular spasm following subarachnoid hemorrhage.
10. Verifying brain death.
11. Mapping of brain perfusion during interventions.

B. For other indications, such as neuropsychiatric disorders and chronic fatigue syndrome, the findings of SPECT brain perfusion imaging have not been fully characterized. In HIV encephalopathy, SPECT brain perfusion imaging can detect organic changes in the brain.

IV. QUALIFICATIONS AND RESPONSIBILITIES OF PERSONNEL

See the [ACR Technical Standard for Diagnostic Procedures Using Radiopharmaceuticals](#).

V. SPECIFICATIONS OF THE EXAMINATION

A. Radiopharmaceuticals

Either Tc-99m HMPAO (exametazime) or Tc-99m-ECD (ethyl cystine dimer/bicisate) is used.

1. Radiopharmaceutical preparation
 - a. Use fresh generator eluate (<2 hours old) for optimal results with Tc-99m HMPAO.
 - b. Do not use pertechnetate obtained from a generator that has not been eluted for 24 hours or more.

2. Radiopharmaceutical injection
 - a. Tc-99m HMPAO: tracer should be injected no more than 4 hours after reconstitution.
 - b. Tc-99m ECD: tracer should be injected no more than 6 hours after reconstitution.
3. Delay time between injection and imaging
 - a. Tc-99m HMPAO: images are obtained \geq 90 minutes after injection for best image quality. Images obtained after a 40-minute delay will be interpretable.
 - b. Tc-99m ECD: for best image quality, a minimum delay of 30 minutes is recommended. Images obtained after a 20-minute delay will be interpretable. It is important to standardize delay time from injection because of slow clearance from areas of high uptake that is significant if delay is more than 2-3 hours.
 - c. Patients should be instructed to void within 2 hours post-injection to minimize radiation exposure.
4. Dosage
 - a. Adults: 370-1110 MBq (10-30 mCi).
 - b. Children 7.4-11.1 MBq/kg (0.2-0.3 mCi/kg). Minimum dose is 3 mCi.
5. Radiochemical purity determinations should be performed on each vial prior to injection using the method outlined in the package insert.

B. Interventional SPECT Imaging

Occasionally a perfusion study is performed following the administration of acetazolamide in patients with cerebrovascular disease to evaluate cerebrovascular reserve.

1. Contraindications
 - a. Known sulfa allergy (skin rash, bronchospasm, and anaphylactic reaction) and advanced liver disease.
 - b. May induce migraine in patients with migraine history.
 - c. Generally avoid within 3 days of acute stroke or recent transient ischemic attack.
2. Protocols
Various protocols have been used. The 2 day technique is simple and preferable. Typically, the challenge portion is performed first. If this is normal, consideration may be given to omitting the baseline study. If a baseline scan is performed, allow sufficient time for residual activity to clear (typically 24 hours).
3. Dosages
Adults receive 1,000 mg by slow IV push for the typical patient. The pediatric dose is 14 mg/kg. Wait 15-20 minutes after administering acetazolamide before injecting tracer.

4. Acetazolamide is a diuretic. The patient should be instructed to void immediately before image acquisition begins. Acquisition and processing are identical to those of a non-acetazolamide study.

C. Patient Preparation

Relevant patient data should be obtained for optimal interpretation of the study. The data should include patient history (including any past drug use or trauma), neurologic and psychiatric findings, mental status examination (e.g., Folstein mini-mental examination or other neuropsychological test), results of recent brain imaging studies (e.g., CT, MRI), current medication, and when last taken.

1. Pre-arrival
Patients should be instructed to avoid caffeine, alcohol, or other drugs known to affect cerebral blood flow (CBF) for at least 24 hours and to avoid smoking cigarettes for at least the day of the test.
2. Pre-injection
 - a. Evaluate the patient for his/her ability to cooperate.
 - b. Explain the procedure to the patient.
 - c. Achieve a consistent environment at the time of injection and uptake:
 - i. Place the patient in a quiet, dimly lit room with no direct light source facing the eyes of the patient. Whether the eyes are covered or the patient is instructed to open or close his/her eyes should be according to department policy and should be followed in all studies.
 - ii. Ensure that the patient is seated or reclining comfortably.
 - iii. Place intravenous access at least 10 minutes prior to injection.
 - iv. Instruct the patient not to speak, read, or move prior to, during, and up to 5 minutes post-injection.
 - d. Ensure no movement by the patient.
3. Precautions
 - a. Demented patients must be closely observed at all times.
 - b. Patients with neurologic deficits may require special care.

D. Image Acquisition

1. The patient should void prior to imaging for maximum comfort during the study.

2. The patient should be positioned for maximum comfort. Minor obliquity of head orientation can be corrected in most systems during processing.
3. The patient's head should be positioned in the middle of the field of view with intercanthal line at 90° angle to the axis of rotation and parallel to the horizontal plane. The head should be lightly restrained to facilitate patient cooperation in minimizing motion during acquisition.
4. If sedation is required, it should be given at least 5 minutes after injection of radiopharmaceutical when possible, and preferably just prior to the acquisition of the study.

E. Data Processing

1. Attenuation correction should be performed in all cases unless a specific application or circumstance dictates otherwise. Use a calculated attenuation correction if available. If slice-specific attenuation correction software is not available, it is acceptable to review non-attenuation corrected images. The contour should include the scalp and should be defined individually for each transaxial slice.
2. Reformat transaxial data into at least three orthogonal planes. Generate transverse sections relative to a repeatable anatomic orientation (e.g., AC-PC line), and coronal and sagittal sections orthogonal to the transverse. Additional sections along a plane parallel to the long axis of the temporal lobes may be useful.

F. Image Interpretation

1. All studies should be interpreted with the knowledge of all the clinical data and the findings of other morphologic imaging modalities.
2. Images should be viewed on a computer display rather than from film or paper copy to permit interactive adjustment of contrast, background subtraction, and color table.
3. Three-dimensional volume renderings may be useful in appreciating overall patterns of disease.
4. The perfusion images should be evaluated with the structural imaging available.
5. Images obtained as part of a seizure evaluation should be correlated with the relevant EEG data and clinical observations. The timing of tracer injection relative to observed seizure activity should be known.
6. The raw data should be reviewed in dynamic cine mode for artifacts and patient motion.

VI. DOCUMENTATION

Reporting should be in accordance with the [ACR Practice Guideline for Communication: Diagnostic Radiology](#).

The report should describe the extent and severity of defects, their correlation with morphologic and clinical abnormalities, and, when relevant, a differential diagnosis and/or the significance of the abnormalities. The report should include the radiopharmaceutical used, the dose injected, the delay period post injection, and any medication administered. The report should also say whether the patient's eyes were open or closed.

VII. EQUIPMENT SPECIFICATIONS

Any gamma camera equipped with a low-energy, high-resolution, ultra-high-resolution, or fan-beam collimator may be used. Either a multiple detector instrument or a dedicated brain imaging system is preferred to a single-head gamma camera system.

A. The smallest radius of rotation possible with appropriate patient safeguards should be used.

B. High-resolution or ultra-high-resolution collimation is recommended.

C. Fan-beam or other focused collimators are preferable to parallel-hole collimators because they provide improved resolution and higher count rates. However, care must be taken to ensure that the entire brain is visualized in all projections to avoid the problem of "incomplete" views. Parallel-hole collimation is acceptable if adequate counts are obtained.

D. A 128 x 128 or greater acquisition matrix is preferred.

E. Angular sampling of 3° or less is recommended.

F. Continuous acquisition may provide shorter total scan duration and reduced mechanical wear to the system when compared to a step-and-shoot technique.

G. Segmentation of data acquisition into multiple sequential acquisitions will permit exclusion of bad data, e.g., removing segments of projection data with patient motion. The scan may be repeated if there is excessive patient motion.

VIII. OTHER CONSIDERATIONS

The American College of Neurology has determined that SPECT brain perfusion imaging has a clinical impact and is acceptable for imaging cerebral perfusion in patients with cerebrovascular accidents, epilepsy, or dementia.

IX. QUALITY CONTROL AND IMPROVEMENT, SAFETY, INFECTION CONTROL, AND PATIENT EDUCATION CONCERNS

Policies and procedures related to quality, patient education, infection control, and safety should be developed and implemented in accordance with the ACR Policy on Quality Control and Improvement, Safety, Infection Control, and Patient Education Concerns appearing elsewhere in the ACR Practice Guidelines and Technical Standards book.

Equipment performance monitoring should be in accordance with the [ACR Technical Standard for Medical Nuclear Physics Performance Monitoring of Nuclear Medicine Imaging Equipment](#).

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