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ACR–SNM–SPR PRACTICE GUIDELINE FOR THE PERFORMANCE OF PULMONARY SCINTIGRAPHY IN ADULTS AND CHILDREN

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 of 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.

Therefore, it should be recognized 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

This guideline was revised collaboratively by the American College of Radiology (ACR), the Society for Pediatric Radiology (SPR), and the Society of Nuclear Medicine (SNM).

It is intended to guide physicians performing pulmonary scintigraphy in adult and pediatric patients. Properly performed ventilation imaging with radioaerosol or gaseous radiopharmaceuticals and perfusion imaging with technetium-99m-labeled perfusion agents that localize by temporary capillary blockade are sensitive tools for detecting certain kinds of pulmonary abnormalities. Correlation with clinical data and current chest radiographs is imperative to optimize the interpretation of images.

Application of this guideline should be in accordance with the ACR Technical Standard for Diagnostic Procedures Using Radiopharmaceuticals.

II. GOAL

The goal of pulmonary scintigraphy is to enable the interpreting physician to detect and, in some cases, to

quantitate abnormalities of pulmonary perfusion and/or ventilation.

III. INDICATIONS AND CONTRAINDICATIONS

Clinical indications for pulmonary scintigraphy include, but are not limited to:

A. Indications

1. Assessment of the probability of acute or chronic pulmonary thromboembolic disease.
2. Evaluation of the presence of chronic pulmonary emboli.
3. Quantification of differential pulmonary function.
4. Evaluation of lung transplants.
5. Evaluation of the effects of congenital heart or lung disease such as cardiac shunts, pulmonary arterial stenoses, and arteriovenous fistulae and their treatment.
6. Confirmation of the presence of bronchopleural fistulae.
7. Evaluation of the effects of chronic pulmonary parenchymal disorders such as cystic fibrosis.
8. Evaluation of arteriovenous fistulae or shunts.

B. Relative Contraindications

There are no absolute contraindications for pulmonary scintigraphy. Potential benefits must outweigh the minor risks of the procedure.

For the pregnant or potentially pregnant patient, see the ACR Practice Guideline for Imaging Pregnant or Potentially Pregnant Adolescents and Women with Ionizing Radiation. When possible the doses of the radiopharmaceuticals used should also be decreased.

IV. QUALIFICATIONS AND RESPONSIBILITIES OF PERSONNEL

See the ACR Technical Standard for Diagnostic Procedures Using Radiopharmaceuticals.

V. SPECIFICATIONS OF THE EXAMINATION

The written or electronic request for pulmonary scintigraphy should provide sufficient information to demonstrate the medical necessity of the examination and allow for its proper performance and interpretation.

Documentation that satisfies medical necessity includes 1) signs and symptoms and/or 2) relevant history (including known diagnoses). Additional information regarding the specific reason for the examination or a provisional diagnosis would be helpful and may at times be needed to allow for the proper performance and interpretation of the examination.

The request for the examination must be originated by a physician or other appropriately licensed health care provider. The accompanying clinical information should be provided by a physician or other appropriately licensed health care provider familiar with the patient's clinical problem or question and consistent with the state's scope of practice requirements. (ACR Resolution 35, adopted in 2006)

A. Pulmonary Perfusion Imaging

1. Radiopharmaceutical

Technetium-99m-labeled macroaggregated human serum albumin (MAA) is the agent used. The administered activity for adults is 3.0 to 5.0 millicuries (111 to 185 MBq) administered intravenously unless the perfusion scan is done before an aerosol scan, when the dose should be 1.0 to 3.0 millicuries (37 to 111 MBq). The injection should be in the supine or close-to-supine position.

Imaging with single head systems should be in the upright (sitting) position, if possible because doing so provides improved visualization at the costophrenic angles. With dual-head systems both the injection and imaging are performed with the patient in the supine position. The range of particle sizes should be between 10 and 90 microns in diameter and should not exceed 150 microns. Between 150,000 and 500,000 particles should be used. For adult patients with known pulmonary arterial hypertension or right-to-left cardiac shunts, the dose and number of particles injected may be decreased, but no fewer than 100,000 particles should be used**.**

Infants and small children, and children with right-to-left shunt or pulmonary hypertension, should receive 10,000 to 30,000 particles depending on the age of the patient and the severity of involvement [1]. The pediatric administered activity should be as low as practically achievable for appropriate image quality.

2. Administration

The patient should be supine for 10 minutes, if possible, prior to injection. To minimize settling and clumping, the vial should be gently agitated before the radiopharmaceutical is withdrawn. The syringe should be agitated prior to injection of the agent for the same reason. A 22-gauge or larger needle is preferred to help reduce the

chance of damage to the particles. Upon injection, care should be taken not to draw blood back into the syringe to avoid formation of clots, which may produce hot emboli on the lung images. When possible, injection should be directly intravenous, avoiding intravenous tubing and use of indwelling catheters. The patient should be as close to supine as possible for injection, and infusion should be slow (10 to 15 seconds). If possible, the patient should cough or take several deep breaths prior to and during the injection.

3. Imaging

   Imaging may begin immediately after the agent has been administered. Preferably 8 and a minimum of 6 views (anterior, posterior, both posterior oblique, and either both anterior oblique or both lateral images) should be obtained for at least 300,000 counts per image if a small crystal (<300 mm in diameter) scintillation camera is used, or 500,000 counts per image, if a large crystal camera is used. Counts per image may be reduced in infants and small children. For critically ill patients who require portable perfusion lung scan imaging, a minimum of 1 anterior view with bilateral anterior oblique views is an acceptable alternative to the usual 6 to 8 views. SPECT imaging may be used as a supplemental or alternative study.

B. Pulmonary Ventilation Imaging

1. Aerosol
   a. Radiopharmaceutical
      Thirty to 50 millicuries (1,110 to 1,850 MBq) of technetium-99m diethylene-triamine pentacetic acid (DTPA) or other approved radiopharmaceutical is placed in a nebulizer and agitated with oxygen. If the aerosol study is performed first, the patient should inhale enough radioaerosol to deposit about 1 millicurie (37 MBq) in the lungs (approximately 100,000 counts per minute). If the ventilation study is performed after a perfusion study, the patient should inhale enough aerosol to triple or quadruple the perfusion count rate.
   b. Administration
      The flow rate should be adjusted to deliver the particle size at or below about 1 micron in diameter. Patient cooperation is required for success of the study. Care should be exercised to prevent spillage of the aerosol into the environment.
   c. Imaging
      The same images as for the perfusion study should be obtained.

2. Xenon-133
   a. Radiopharmaceutical
      Xenon-133, a radioactive gas is administered by mask and requires a delivery and trapping system or external exhaust system. The usual administered activity for adults is 10 to 30 millicuries (370 to 1,110 MBq). The administered activity for children is 0.3 millicuries/kg (11.1 to 1,110 MBq/kg) with a minimum of 3.0 millicuries (111 MBq).
   b. Administration
      A special room with negative pressure ventilation is desirable. Patient cooperation is required for success of the study. Care should be exercised to prevent spillage of the agent into the environment. Patients who are severely dyspneic or who are on ventilator support may not be able to undergo xenon-133 ventilation imaging.
   c. Imaging
      The ventilation phase is usually, but not always, performed before the perfusion phase. Three sets of images are usually obtained, nearly always in the posterior projection. The first is a breath-holding view of the first deep breath after introduction of the agent ("inhalation view"). The second is an "equilibration" phase, during which the patient rebreathes the xenon-133 and oxygen**,** usually for 2 to 3 minutes, and 1 or 2 images are acquired. The third is the "wash-out phase," during which the patient inhales room air, possibly mixed with oxygen, but exhales into the xenon-133 trap. Serial images are obtained at 15 to 60 second intervals for 5 minutes or until wash-out is complete, whichever comes first. Right and left posterior oblique equilibrium images may also be obtained early in the "equilibrium phase" and/or during wash-out (typically obtained during the third and fourth minutes of wash-out), to provide additional information about the location of ventilation abnormalities.

VI. EQUIPMENT SPECIFICATIONS

For small-crystal (<300 mm in diameter) scintillation cameras, a diverging collimator is desirable. For larger crystal scintillation cameras, low-energy all-purpose/general all-purpose (LEAP/GAP) or high-resolution collimators are desirable. Large-field cameras

with parallel-hole collimators provide less distortion than diverging collimators.

VII. OTHER CONSIDERATIONS

Most studies are performed to assess possible acute pulmonary thromboembolic disease. Several basic interpretation criteria have been validated and may be used for guidance. Pulmonary scintigraphy does not directly identify pulmonary emboli but is useful in establishing a probability of pulmonary embolism and aids in the decision about whether a patient would benefit from other imaging studies (e.g., computed tomography (CT) pulmonary angiography**,** catheter pulmonary angiography, and/or duplex lower extremity sonography).

For patients being studied for acute pulmonary embolic disease, current chest radiographs, preferably posteroanterior and lateral should be obtained and inspected by the interpreting physician to ascertain whether confounding conditions (e.g., pneumonias, tumors, congestive heart failure, pleural effusions, pneumothoraces) are present. Optimally the radiographs should be obtained immediately before or after the study, but no later than 24 hous from the time of the lung scan or other acute symptoms.

If available, prior pulmonary scintigrams, chest CT, or abdominal CT (if the abdominal CT examination includes the lower lungs) should be reviewed to evaluate for chronic unresolved pulmonary embolic or other persistent abnormalities.

Quantitative measures of relative lung perfusion (comparing lungs or dividing each lung into thirds and calculating the percentage of total counts in each region) may be useful in nonembolic and preoperative disease assessment and evaluation of post-lung transplant patients [2,3]. Quantitative comparison of regional perfusion and ventilation may also be useful.

If a patient with an abnormal lung scan is diagnosed as having pulmonary emboli, a follow-up perfusion lung scan should be considered to establish a baseline for continued evaluation, particularly in patients with comorbid cardiopulmonary disease and/or a large initial perfusion deficit. Preferably, this follow-up study should be performed 1 to 3 months following the initial thromboembolic episode [4].

VIII. DOCUMENTATION

Reporting should be in accordance with the ACR Practice Guideline for Communication of Diagnostic Imaging Findings.

The report should include the radiopharmaceutical used and the dose and route of administration, as well as any other pharmaceuticals administered, also with dose and route of administration.

IX. RADIATION SAFETY

Radiologists, imaging technologists, and all supervising physicians have a responsibility to minimize radiation dose to individual patients, to staff, and to society as a whole, while maintaining the necessary diagnostic image quality. This concept is known as "as low as reasonably achievable (ALARA)."

Facilities, in consultation with the radiation safety officer, should have in place and should adhere to policies and procedures for the safe handling and administration of radiopharmaceuticals, in accordance with ALARA, and must comply with all applicable radiation safety regulations and conditions of licensure imposed by the Nuclear Regulatory Commission (NRC) and by state and/or other regulatory agencies. Quantities of radiopharmaceuticals should be tailored to the individual patient by prescription or protocol.

X. QUALITY CONTROL AND IMPROVEMENT, SAFETY, INFECTION CONTROL, AND PATIENT EDUCATION

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 appearing under the heading *Position Statement on QC & Improvement, Safety, Infection Control*, *and Patient Education* on the ACR web page (http://www.acr.org/guidelines).

Equipment performance monitoring should be in accordance with the ACR Technical Standard for Medical Nuclear Physics Performance Monitoring of Gamma Cameras.

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Suggested Reading (Additional articles that are not cited in the document but that the committee recommends for further reading on this topic)

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