The American College of Radiology, with more than 30,000 members, is the principal organization of radiologists, radiation oncologists, and clinical medical physicists in the United States. The College is a nonprofit professional society whose primary purposes are to advance the science of radiology, improve radiologic services to the patient, study the socioeconomic aspects of the practice of radiology, and encourage continuing education for radiologists, radiation oncologists, medical physicists, and persons practicing in allied professional fields.

The American College of Radiology will periodically define new practice guidelines and technical standards for radiologic practice to help advance the science of radiology and to improve the quality of service to patients throughout the United States. Existing practice guidelines and technical standards will be reviewed for revision or renewal, as appropriate, on their fifth anniversary or sooner, if indicated.

Each practice guideline and technical standard, representing a policy statement by the College, has undergone a thorough consensus process in which it has been subjected to extensive review, requiring the approval of the Commission on Quality and Safety as well as the ACR Board of Chancellors, the ACR Council Steering Committee, and the ACR Council. The practice guidelines and technical standards recognize that the safe and effective use of diagnostic and therapeutic radiology requires specific training, skills, and techniques, as described in each document. Reproduction or modification of the published practice guideline and technical standard by those entities not providing these services is not authorized.

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ACR PRACTICE GUIDELINE FOR THE PERFORMANCE OF PULMONARY SCINTIGRAPHY

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

This guideline was developed by the American College of Radiology (ACR) to guide physicians performing pulmonary scintigraphy in adults 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 for correct 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 or ventilation.

III. INDICATIONS

Clinical indications for pulmonary scintigraphy include, but are not limited to: assessing the probability of acute or chronic pulmonary thromboembolic disease; establishing the presence of chronic, unresolved pulmonary emboli; quantifying of differential pulmonary function; evaluating lung transplants; evaluating the effects of congenital heart/lung disease; confirming the presence of bronchopleural fistulae; and evaluating the effects of chronic pulmonary parenchymal disorders such as cystic fibrosis.

IV. QUALIFICATIONS AND RESPONSIBILITIES OF PERSONNEL

See the ACR Technical Standard for Diagnostic Procedures Using Radiopharmaceuticals.

V. SPECIFICATIONS OF THE EXAMINATION

A. Pulmonary Perfusion Imaging

1. Radiopharmaceutical

   Technetium-99m-labeled macroaggregated human serum albumin (MAA) is the agent used. The administered activity for adults is 3.0-5.0 millicuries (111-185 MBq) administered intravenously. Injection should be in the supine or close-to-supine position, but imaging should be in the upright (sitting) position, if possible, because doing so provides improved visualization at the costophrenic angles. If performed prior to aerosol imaging, the administered activity for adults is 1.0-3.0 millicuries (37-111 MBq). 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. In patients with pulmonary hypertension or right-to-left shunt, or in infants and children, the number of particles should be reduced, but no fewer than 100,000 particles should be injected. The minimum pediatric administered activity is 15-50 microcuries/kg (0.04-1.4 MBq/kg) with a maximum of 200 microcuries (7.4 MBq). The pediatric administered activity should be as low as practically achievable for appropriate image quality.

2. Administration

   The patient should be supine 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. Injection should commence promptly after blood drawn back from the vein enters the syringe. This will help avoid the formation of radiolabeled clots in the syringe. When possible, injection should be directly intravenous, avoiding intravenous tubing and veins in which phlebitis or thrombi are present. The patient should be as close to supine as possible for injection, and infusion should be slow (10-15 seconds). 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. A minimum of six 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 diameter) scintillation camera is used, or 500,000 counts per image, if a large crystal camera is used. For critically ill patients who require portable perfusion lung scan imaging, a minimum of one anterior view with bilateral anterior oblique views is an acceptable alternative to the usual six views.

B. Pulmonary Ventilation Imaging

1. Aerosol

   a. Radiopharmaceutical
      An administered activity of 30-50 millicuries (1,110-1,850 MBq) of technetium-99m diethylenetriamine penta-cetic acid (DTPA) or other approved radiopharmaceuticals. The approved radio-pharmaceutical is placed in a nebulizer and agitated with oxygen.
   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. If the aerosol study is

done first, the patient should inhale enough radioaerosol to deposit about 1 millicurie (37 MBq) (approximately 100,000 counts per minute). If the imaging is performed after a perfusion study, the patient should inhale enough aerosol to triple or quadruple the perfusion count rate.

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 10-30 millicuries (370-1,110 MBq). The administered activity for children is 0.3 millicuries/kg (11.1-1,110 MBq/kg) with a minimum of 3.0 millicuries (111 MBq).
   b. Administration
      A special room with negative pressure ventilation is required. 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 for 2-3 minutes and one or two images are acquired. The third is the "washout phase," during which the patient inhales room air, possibly mixed with oxygen, but exhales into the xenon-133 trap. Serial images are obtained at 15-60 second intervals for 5 minutes or until washout is complete, whichever comes first. Right and left posterior oblique equilibrium images may also be obtained early in the "equilibrium phase" and/or during washout to provide additional information about the location of ventilation abnormalities.

VI. EQUIPMENT SPECIFICATIONS

Perfusion Imaging (Tc-99m MAA) and Ventilation Imaging using Radioaerosols and Xenon-133

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 fewer distortions 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 of which patient would benefit from other imaging studies (e.g., pulmonary angiography, helical (spiral) computed tomography or Doppler sonography).

For patients being studied for acute pulmonary embolic disease, current chest (preferably posteroanterior and lateral) radiographs (within 24 hours of the lung scan or after acute symptoms) 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.

If prior pulmonary scintigrams are available, they 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 disease. Quantitative comparison of regional perfusion and ventilation may also be useful.

If a patient with an abnormal lung scan is diagnosed to have pulmonary emboli, consideration should be given to repeating a perfusion lung scan to establish a baseline for continued evaluation, particularly in patients with comorbid cardiopulmonary disease and/or a large initial perfusion deficit. Preferably, this should be performed after any anticoagulation therapy is discontinued.

VIII. DOCUMENTATION

Reporting should be in accordance with the ACR Practice Guideline for Communication: Diagnostic Radiology.

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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