

# Pulmonary (V/Q) Imaging

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**P**ulmonary ventilation/perfusion lung imaging is performed to assess the lung's airflow and arterial blood supply. The procedure is most commonly performed for the assessment of pulmonary embolism.

## Clinical Indications

- Identification of chronic or acute pulmonary embolism
- Documentation of the resolution of pulmonary embolism
- Quantification of differential function before pulmonary surgery (i.e., lung cancer)
- Evaluation of lung transplants
- Congenital heart defects or lung disease such as cardiac shunts, pulmonary arterial stenosis, and arteriovenous fistula
- Confirmation of the presence of bronchopleural fistulae
- Evaluation of the effects of chronic pulmonary parenchymal disorders such as cystic fibrosis
- Evaluation of alveolar clearance and/or function (i.e., smoking history and inhalation or other environmental injury or exposure)
- Evaluation of the cause of pulmonary hypertension

## Contraindications

- Medically, there are no contraindications to pulmonary (V/Q) imaging; however, caution should be taken in the following situations: (1) Pregnancy/lactation—pregnancy requires careful risk versus benefit assessment associated with fetus exposure. Radiation safety instructions are required for lactating patients. (2) Recent nuclear medicine studies (isotope dependent). (3) Documented hypersensitivity reactions.

## Patient Preparation/Education

- Patient may eat and take medications as prescribed.
- Assessment of pregnancy or lactation for all women of child-bearing age.
- Recent posterior/anterior and lateral chest radiograph or chest CT (within 24 hours of scan). An anterior portable chest radiograph is acceptable when a standard chest radiograph is not possible.

- Obtain a focused clinical history including: current symptoms (e.g., shortness of breath, chest pain, fever, and cough); relevant personal history (e.g., recent surgery, cancer, and pulmonary disease); history/treatment of previous deep vein thrombosis or pulmonary embolism; current medications including anticoagulants; and recent imaging procedures (obtain images and interpretation of studies).

Patient education should include a detailed description of the procedure including time to completion for each imaging sequence, required patient position during each imaging sequence, and demonstration of how the mouthpiece or mask and nose clip are used during the ventilation study.

Unless directed by facility protocol or specific request of the ordering physician, the ventilation study is acquired prior to the perfusion study.

## Acquisition Instructions: Gas

- Lung ventilation should be performed with the patient upright whenever possible and the patient positioned in front of the camera to acquire a posterior image.
- A mouthpiece or mask and nose clip are connected through a bacterial filter to the gas delivery system.
- The procedure is performed in three phases:
  - Single breath: the patient is instructed to take a deep breath and exhale. The gas is introduced into the system, and the patient is instructed to take a deep breath and hold it for as long as possible or until instructed to exhale.
  - Equilibrium: the patient is instructed to breathe normally through the delivery system containing the gas and oxygen mixture for approximately 2–3 minutes. Four dynamic images (45 seconds/view) are acquired during this time.
  - Washout: the gas is vented into the trap as the patient continues to breathe room air mixed with oxygen. Serial dynamic images (15–60 seconds each) are acquired for approximately 5 minutes or until washout is complete.

## Acquisition Instructions: Aerosol

- Lung ventilation should be performed with the patient upright whenever possible.
- The patient inhales the aerosol through a mouthpiece or mask connected to an oxygen-agitated nebulizer until the count rate in the lungs is approximately 100,000 cpm.
- Planar or SPECT images are acquired immediately. Planar images should include anterior, right anterior oblique, right lateral, right posterior oblique, posterior, left posterior oblique, left lateral, and left anterior oblique. Optional SPECT images are acquired with the patient's arms above the head and camera rotation set to include the full lung region.

## Acquisition Instructions: Perfusion

- Gently agitate the syringe or vial before injection. **Caution:** do NOT draw blood into the syringe.
- The injection is administered with the patient supine.
- Instruct the patient to cough, then take several deep breaths prior to administration of the radiopharmaceutical.
- Inject the <sup>99m</sup>Tc-macroaggregated albumin slowly.
- Planar images are acquired in the anterior, right anterior oblique, right lateral, right posterior oblique, posterior, left posterior oblique, left lateral, and left anterior oblique projections (500,000 to 1 million counts/view).

Instrumentation Imaging Parameters

Camera type	Large field of view (single or multidetector)
Energy peaks	140 keV ( <sup>99m</sup> Tc) 81 keV ( <sup>133</sup> Xe) 190 keV ( <sup>81m</sup> Krypton)
Energy window	20%
Collimator	Low-energy all-purpose or high-resolution
Matrix	128 × 128 (ventilation/SPECT) 256 × 256 (planar)
SPECT	
Orbit	360° (non-circular preferred)
Number of projections	60—single head (6°) 120—dual head (3°)
Time/projection	10 seconds/projection (aerosol) 20–30 seconds/projection (perfusion)
Acquisition type	Step-and-shoot or continuous

Radiopharmaceuticals—Gas		
Identity	Dose	Route of administration
<sup>133</sup> Xe gas	100 MBq (5 mCi) Range: 200–750 MBq (5–20 mCi) Pediatric dose: 10–12 MBq/kg (0.3 mCi/Kg)— minimum dose, 100–120 MBq (3 mCi)	Continuous inhalation
<sup>81m</sup> Krypton (not available in the United States)	40–400 MBq (1–10 mCi)	Continuous inhalation
Radiopharmaceutical—Aerosol		
Identity	Dose	Route of administration
<sup>99m</sup> Tc-diethylenetriamine pentaacetic acid (DTPA) aerosol	900 MBq (25 mCi) Range: 900–1,300 MBq (25–35 mCi)	Continuous inhalation
<sup>99m</sup> Tc-sulfur colloid aerosol	900 MBq (25 mCi) Range: 900–1,300 MBq (25–35 mCi)	Continuous inhalation
Radiopharmaceutical—Perfusion		
Identity	Dose	Route of administration
<sup>99m</sup> Tc-macroaggregated albumin (MAA)	40 mBq (1 mCi) Range: 40–150 MBq (1–4 mCi) 200,000–700,000 particles Pediatric dose: 1.11 MBq/kg (0.03 mCi/kg) 2.59 MBq/kg (0.07 mCi/kg) if <sup>99m</sup> Tc aerosol study performed Minimum activity: 14.8 MBq (0.4 mCi)	Intravenous

- Optional SPECT imaging is performed with the patient's arms above the head and camera rotation set to include the full lung region.
- For SPECT/CT protocols, refer to the manufacturer's recommendations for CT acquisition parameters.

### Imaging Processing

- Planar images should be scaled to clearly visualize increased or deficit radiopharmaceutical distribution.
- SPECT images should be processed per the manufacturer's recommendations and interpreting physician's preference including filter selection (filtered back projection or iterative reconstruction recommended) and image display (transverse, sagittal, and coronal views).
- SPECT/CT images can be fused for attenuation correction and correlative interpretation.
- For lung quantification: place regions of interest over the right and left lung fields in both the anterior and the posterior projections.
- On the anterior and posterior views, divide each lung into 3 equal rectangular segments (top, middle, and bottom).
- Determine total activity for each lung as well as activity in all 6 regions of interest. Calculate geometric mean – square root of the product of the anterior counts multiplied by the posterior counts for all lung regions. **Note:** the geometric mean is used because it is more representative than the arithmetic mean (anterior counts plus posterior counts divided by 2).
- Calculate the percentage of counts in each region and each lung.
- The normal right–left lung ratio is 55:45.
- If the results of the pulmonary function forced expiratory volume in 1 second test are available, the results can be converted to milliliters and multiplied by the percentage uptake for each lung to predict postsurgical expiratory volume.

### Adjunct Imaging/Intervention

- Gas/perfusion: bronchodilator therapy can improve the accuracy of the study with patients with acute obstructive lung disease.
- Perfusion: imaging can be delayed for patients with congestive heart failure until after initiation of therapy for heart failure. If kidney visualization occurs, additional images of the head should be taken to differentiate free pertechnetate from right-to-left shunt.

### Precautions

- Gas/aerosol: none.
- Perfusion:
  - o Do **NOT** pull blood back into syringe (clotting may result displaying hot spots on lung images).
  - o Indwelling catheters should be flushed before injection.
  - o Use of a central line for injection can result in inadequate mixing of activity in the pulmonary artery and inadequate distribution of activity.
  - o Do not administer activity into the distal port of Swan–Ganz catheter or any indwelling line or port containing a filter.
  - o Patients with pulmonary hypertension, right-to-left shunts, and pneumonectomy should receive a reduced number of particles or half the dose.

### REFERENCES

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