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Ventilation Lung Imaging: Technegas*

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RATIONALE

Ventilation lung imaging is performed to evaluate lung function related to bronchopulmonary air distribution into and out of the lungs. Technegas (Cyclomedica Asia Pacific) is a system for producing ^{99m}Tc-based ventilation studies using a carbon-based nanoparticle. Technegas is not a gas and does not produce aerosolized particles.

CLINICAL INDICATIONS

- Detection of pulmonary embolism and recurrent pulmonary embolism.
- Documentation of pulmonary embolism resolution.
- Evaluation of quantitative lung function (i.e., lung cancer).
- Evaluation of lung transplants.
- Evaluation of congenital heart defects or lung diseases such as the following:
  - Cardiac shunts.
  - Pulmonary arterial stenosis.
  - Arteriovenous fistula.
- Confirmation of bronchopleural fistula.
- Evaluation of chronic pulmonary parenchymal disorders such as cystic fibrosis.
- Evaluation of pulmonary hypertension.

CONTRAINDICATIONS

- Pregnancy must be excluded according to local institutional policy. If the patient is breastfeeding, appropriate radiation safety instructions should be provided.
- Recent nuclear medicine study (radiopharmaceutical-dependent).

PATIENT PREPARATION/EDUCATION

- The patient may eat and take medications as necessary before the procedure.
- Chest radiography in both the posterior–anterior and the lateral projections or chest CT, ideally performed within 4 h of the scan (acceptable ≤24 h before the scan or since a recent change in clinical status), is required to correlate with the lung scan. An anterior portable chest radiograph is acceptable when a standard chest radiograph is not possible.
- A focused history containing the following elements should be obtained:
  - Signs and symptoms (e.g., shortness of breath, chest pain, fever, cough, syncope, tachycardia, jugular venous distention, or hemoptysis).
  - Relevant history, including known diagnoses (e.g., recent surgery, cancer, chronic obstructive pulmonary disease, immobility, or obesity).
  - Results of D-dimer test if ordered.
  - History of prior deep venous thrombosis or pulmonary embolism.
  - Results of images of prior lung scans.
  - Pertinent findings on radiography of the chest.
  - Treatment with anticoagulant or thrombolytic therapy.
  - Results of tests for deep venous thrombosis and other imaging procedures.
- Educating, and practicing the procedure with, the patient before inhalation of the Technegas is critical to procedure success.
  - The practice session should be done under the same conditions as the actual ventilation procedure, including position (upright or supine) and using the nose clip.
  - The practice session improves timing, ventilation, and patient compliance (especially with the seal) and offers the opportunity to select the appropriate mouthpiece for that patient.

RADIOPHARMACEUTICAL IDENTITY, DOSE, AND ROUTE OF ADMINISTRATION

- The radiopharmaceutical identity, dose, and route of administration are described in Table 1.

PROTOCOL/ACQUISITION INSTRUCTIONS

- The acquisition parameters for planar imaging and for SPECT or SPECT/CT can be found in Tables 2 and 3, respectively.

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TABLE 1
Radiopharmaceutical Identity, Dose, and Route of Administration

Identity	Dose	Route of administration
^{99m}Tc-pertechnetate ($^{99m}TcO_4$)	200 MBq (5.5 mCi); range, 200–900 MBq (5.5–25 mCi)	Inhalation

Lung count rate in posterior position should be about 1,000–1,500 counts/s, equating to 20–50 MBq delivered to lungs.

System Preparation

- Connect and turn on the argon supply flow rate to 15 L/min.
- Connect to the main power supply, and switch on.
- Press the "open" button to open the chamber.

Crucible Preparation

- Using gloves and forceps, clear debris from the chamber and ash tray.
- Wet the well of a new crucible with ethanol and drain, but do not allow it to dry.
- Use forceps to place the crucible between the chamber contacts, and ensure good contact by rotating forward and backward. Take care not to twist or fracture the crucible.
- Add 200–900 MBq of ^{99m}Tc-pertechnetate in 0.13–0.17 mL with the well vertical, but do not overfill the crucible.
- Depress and hold the draw interlock and the close button until the chamber is completely closed.

Simmer

- Press the start button to initiate the 15-s burn.
- Verify the burn, and then disconnect the main and argon.
- Transport the Technegas generator to the patient.
- Administer the Technegas within a 10-min window.

Patient Ventilation

- Attach the patient administration set to the Technegas generator.
- Commence the practiced breathing strategy with the patient.
- Press the start button.
- On inspiration, depress the patient delivery knob.
- Monitor the lung count rate.
- When a rate of 1,500–2,500 counts/s in the posterior position is achieved, release the delivery knob and allow the patient to take 1–3 breaths through the tube to clear the residual.
- Dispose of the patient administration set.
- Return the Technegas generator to argon and main power supply, which will automatically commence a purge.

Ventilation Imaging

- Begin imaging immediately after completion of the delivery of the radioactive aerosol.
- Acquire planar images in multiple projections, to include anterior, right anterior oblique, right

TABLE 2
Acquisition Parameters: Planar

Parameter	Specification	Standard/preferred/optional
Camera type	Large field of view	Standard
Energy peak	140 keV	Standard
Energy window	20%	Standard
Collimator	Low-energy, high-resolution	Standard
Patient position	Supine	Standard
Camera position	Lungs within field of view	Standard
Inhalation-to-imaging time	Acquisition started on completion of inhalation	Standard
Acquisition type	Static	Standard
Views	Anterior, posterior, right anterior oblique, left anterior oblique, right posterior oblique, left posterior oblique, right lateral, and left lateral	Standard
Additional views	NA	NA
Matrix	256 × 256	Standard
Number of views	8	Standard
Counts/view	300,000–500,000 (corresponding perfusion images should acquire 800,000–1,000,000 counts)	Standard
Additional images: time per view	NA	NA

NA = not applicable.

TABLE 3
Acquisition Parameters: SPECT or SPECT/CT

Parameter	Specification	Standard/preferred/optional
Camera type	Large-field-of-view multidetector	Standard
Energy peak	140 keV	Standard
Energy window	20%	Standard
Collimator	Low-energy, high-resolution	Standard
Patient position	Supine	Standard
Camera position	Lungs within field of view	Standard
Inhalation-to-imaging time	Acquisition started on completion of inhalation	Standard
Acquisition type	Step and shoot or continuous	Standard
Orbit	180° or 360°	Standard
Orbit type	Noncircular	Standard
Matrix	128 × 128	Standard
Number of projections	120	Standard
Time per projection	12–15 s	Standard
CT acquisition	Per manufacturer's recommendations for attenuation correction or diagnostic imaging	Optional

lateral, right posterior oblique, posterior, left posterior oblique, left lateral, and left anterior oblique.
- SPECT imaging is optional. Position the patient supine on the imaging table with arms above head and out of the field of view. Set the camera to acquire a SPECT scan of the chest region such that the entire lung is in the field of view.

Common Options

- CT may be performed with the SPECT camera and can be low-dose, nondiagnostic CT for attenuation correction, diagnostic CT, or a CT pulmonary angiogram.

IMAGING PROCESSING

- Planar images should be scaled to visualize areas of uptake or absence of tracer.
- SPECT images should be processed per the manufacturer's recommendation and the interpreting physician's preference, including preprocessing, reconstruction (transverse, sagittal, and coronal views), filter selection, and image display.
- Iterative reconstruction is recommended.
- If SPECT/CT is performed, images can be fused for attenuation correction and correlative interpretation.
- For SPECT/CT protocols, refer to the manufacturer's recommendations for CT acquisition parameters.
- For quantitative ventilation lung scans:
  - Place regions of interest over the right and left lungs in both the anterior and posterior projections.
  - Divide each lung into 3 equal rectangular regions of interest on the anterior and posterior views: top, middle, and bottom. The division of the lungs into thirds does not exactly correlate with the anatomic divisions of the lung lobes but is reasonably representative.
  - Determine the total activity for each lung in addition to the activity in all 6 regions of interest.
  - Calculate the geometric mean: the square root of the product of the anterior counts multiplied by the posterior counts ($\sqrt{}$ [anterior counts × posterior counts]) for all lung regions. The geometric mean is used because it is more representative than the arithmetic mean ([anterior counts + posterior counts]/2).
  - Calculate the percentage of counts in each region.

ADJUNCT IMAGING/INTERVENTIONS

- Bronchodilator therapy can improve study accuracy in patients with acute obstructive lung disease.

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