VQ LUNG SCAN

Acquisition and Processing

Brant Community Healthcare System:

- We perform a large volume of VQ scans each year.
- In 2014, we performed 685 scans-most were to rule out PE; approx. 5% for follow-up for resolution.

VQ Acquisition

- 2 parts: Ventilation and Perfusion
- Images can be acquired as planar, SPECT, or SPECT/CT
- The count rate of the perfusion study must be 3-4 times the count rate of the ventilation study if using Tc for both
- Ventilation imaging should be performed before perfusion imaging as it is more difficult to deliver a larger dose of aerosol than it is to deliver a larger dose of Tc99m MAA (SNM guidelines)

Patient History

- CXR or chest CT performed within 24 hours
- D dimer results
- Any history of previous DVT or PE?
- List of medications, particularly anticoagulants or thrombolytics
- Lung surgery?
- R/O pregnancy

Perfusion:

- 40-150 MBq of Tc99m MAA which localizes by capillary blockade (95% removed with first pass)
- Particle size ranges from 5-100 um
- Biological half-life in the lungs ranges from 1.5-4hrs
- Number of particles injected should be in the range of 200,000-700,000
- Reduced number of particles should be used in cases of right-to-left shunt, or pulmonary hypertension (<200 000)

Perfusion:

- MAA particles tend to settle in vials/syringes. Vials should be gently inverted several times before doses are drawn, and syringes should be inverted before doses are administered.
- Have patients take several deep breaths before injecting MAA slowly and with patient supine (to minimize perfusion gradient apex and base of lung)

Ventilation: Aerosols

- 99mTc-DTPA, or 99mTc-sulfur colloid
- Particle size mean is 0.5 um
- Low cost, readily available, allows for multiple views to be obtained
- Not true gas hence not true functional image, no washout images, less assessment of distal airway (better with smaller aerosol particles)
- COPD imaging is compromised
- Have to do ventilation first

Aerosol Administration

- Dose of 900-1300MBq in 2mL is injected into the nebulizer unit, delivering a dose of 20-40MBq to the patient
- Oxygen at a flow rate of 7-10L/min is hooked up and the patient breathes normally through a mouthpiece (nose clip in place) for 3-5 min
- Possibility of contamination if patient removes mouthpiece or does not keep a tight seal with their lips when breathing (best to do this away from the camera!)

Ventilation: Xe-133

- Gamma energy of 81keV, T1/2 5.2 days
- Easily shielded
- True ventilation image
- Single breath, wash in, equilibrium and wash out assessment is possible
- Most sensitive agent for detection of airway disease

Ventilation: Xe-133

Disadvantages:

- Need to trap and decay store
- Challenge to administer, requires a lot of patient cooperation
- Poor resolution (81kev)
- Single or very limited views (usually post)
- Must do ventilation first

Ventilation: Kr-81m

- 190keV, T1/2 of 13 sec, better image resolution
- No exhaust or trap and storage required
- Multiple views possible
- Can do perfusion first

<u>Disadvantages:</u>

- Higher cost
- No single breath or washout information
- Rb-81 Generator required daily

Ventilation: what's ideal?

- Tc labelled for optimal resolution
- Gas-like behavior for **true** functional image
- Low risk for contamination
- Not compromised by patient conditions
- Flexible imaging protocols
- Truly complement the superior image quality of the perfusion image.

Ventilation: Technegas

- An alternative to the traditional aerosol systems is Technegas.
- Pure Pertechnetate , preferably in concentrated form
- A dose of 350-700 MBq (avg. is approx. 500MBq) is used
- The pertechnetate needs to be high assay, as the volume to be used is only 0.14mL

Ventilation: Technegas

- Technically, it is a micro-aerosol of graphitic particles containing pure 99mTc metal. The 99mTc particle is completely surrounded by carbon so that only the carbon surface is presented to the external environment.
- The particles are hydrophobic so they do not grow in size as they penetrate the lung tissue

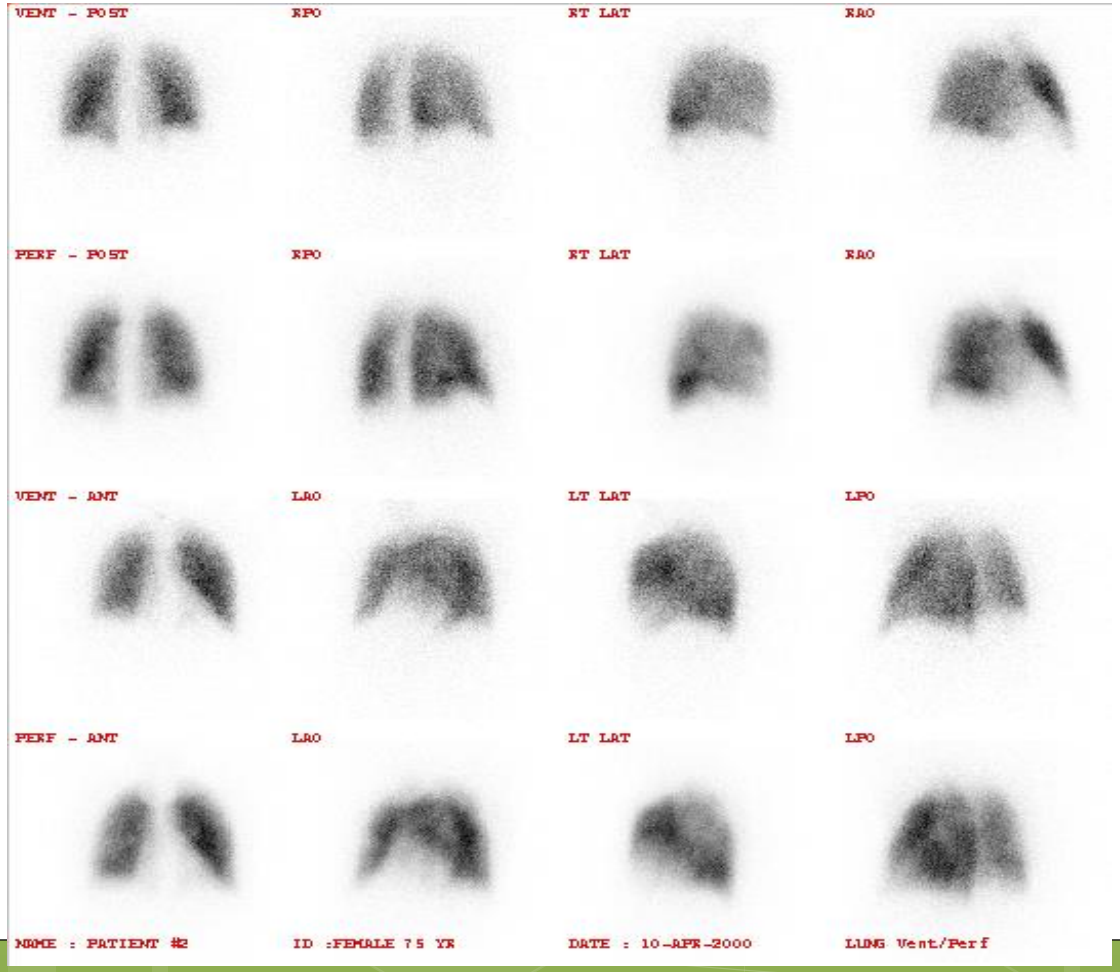
Ventilation: Technegas

- Structured ultra-fine dispersion of Tc99m labeled carbon:

  Hexagonal platelets of metallic Technetium contained within a thin layer of graphite carbon.
- Particles are 20-80 nm and behave like a gas.
- Particles diffuse to the walls of the alveoli where they remain.
- Distribution reflects true ventilation and the image is stable.
- Thus once the desired count-rate has been achieved the Technegas will remain in the lungs for the lifetime of the Tc99m

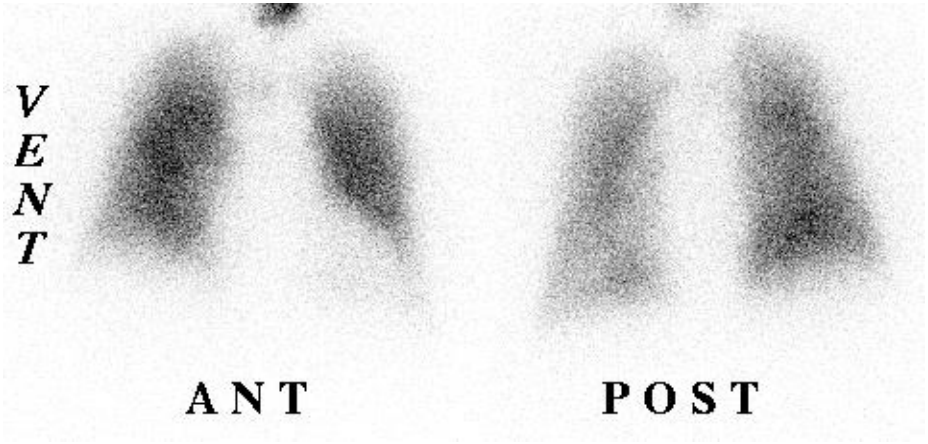
Technegas-Image Appearance

- Ventilation→
- Perfusion→
- Ventilation→
- Perfusion→

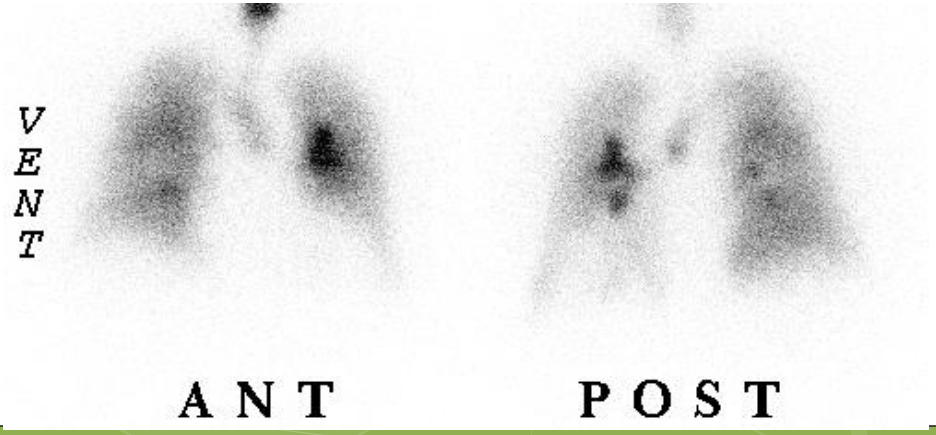


Technegas: Image Comparison

- Technegas:



- 99mTc aerosol:



Technegas: Fits ideal model

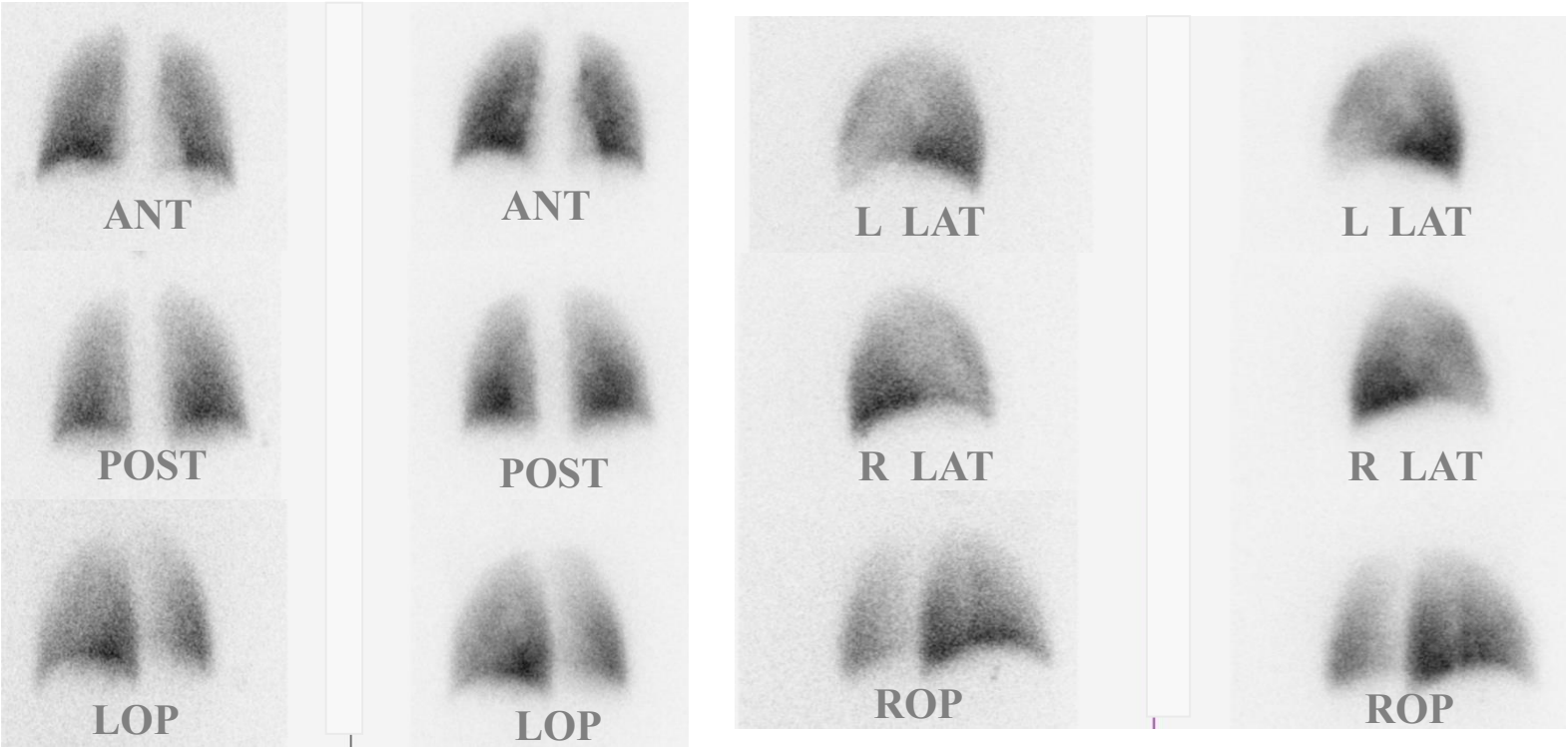
- Tc99m label
- No hot spots on images
- Easy to administer to the patient via normal breathing
- Rapid administration….2-4 breaths!
- Consistent and controlled patient doses

Technegas: Fits ideal model

- Exceptional image quality
  - True ventilation image
  - View to view matching to perfusion…any view
  - Homogenous distribution
- COPD and other complications are diagnostic
- Less potential of radiation exposure to technologists and patients, due to rapid inhalation & shielding

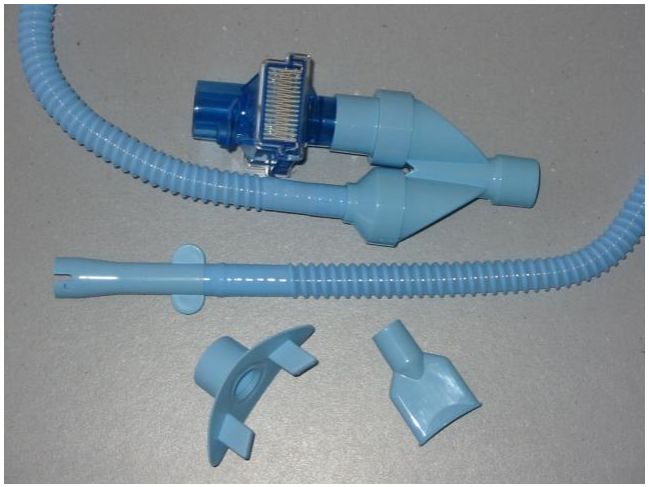
Technegas-Normal images

- Vent Perf Vent Perf



Technegas- what does it look like?

Technegas Generator and Delivery System



Single use, Patient Administration Set (PAS)

Technegas-How does it work?

- The Technegas generator is essentially a high heat furnace.
- The heating element is made from 100% spectroscopic graphite
- Crucibles of high purity graphite with a hollowed section for loading the pertechnetate will become the hottest part of the machine when electric current is passed through it.

Technegas-How does it work?

- The crucible is filled with 0.14mL sodium pertechnetate (dose of 350-700MBq)
- The 6 minute simmer cycle starts: Argon gas blows across the top of the crucible, warming it to 70°C. The liquid in the crucible will dry up and the whole chamber is purged with pure argon.
- During the "burn" phase, the temperature rises to 2550°C for 15sec. This fills the chamber with Technegas

Technegas-How does it work?

- Once prepared, there is a 10 minute window in which to use the Technegas.
- Following patient administration the chamber needs to complete a 3 minute purge cycle before reloading for the next patient.

Technegas-How does it work?

- <u>Caution on argon use:</u>
- Pure argon is critical for proper Technegas production. Traces of oxygen as low as 0.1% will produce some Pertechnegas. Pertechnegas is absorbed rapidly through the lung directly into the bloodstream.
- Ultra-pure argon should be used

Technegas-patient administration

Patient inhales the Technegas using the patient administration set.

Nose clamps are used to encourage breathing through the mouthpiece

Patient should be supine whenever possible

A mask can be used on the PAS if patient has difficulty breathing

Technegas-patient administration

Patient takes an EASY 2-4 breaths of Technegas.

Patient asked to hold breath 2-3 secs…if possible. If not, that is OK.

Button on machine or remote will control what the patient breathes.

Target 1500-2000 cps-measured over the chest

Exhaled breath is filtered by ‘trap’ on PAS which clears 100% Tc99m from breath.

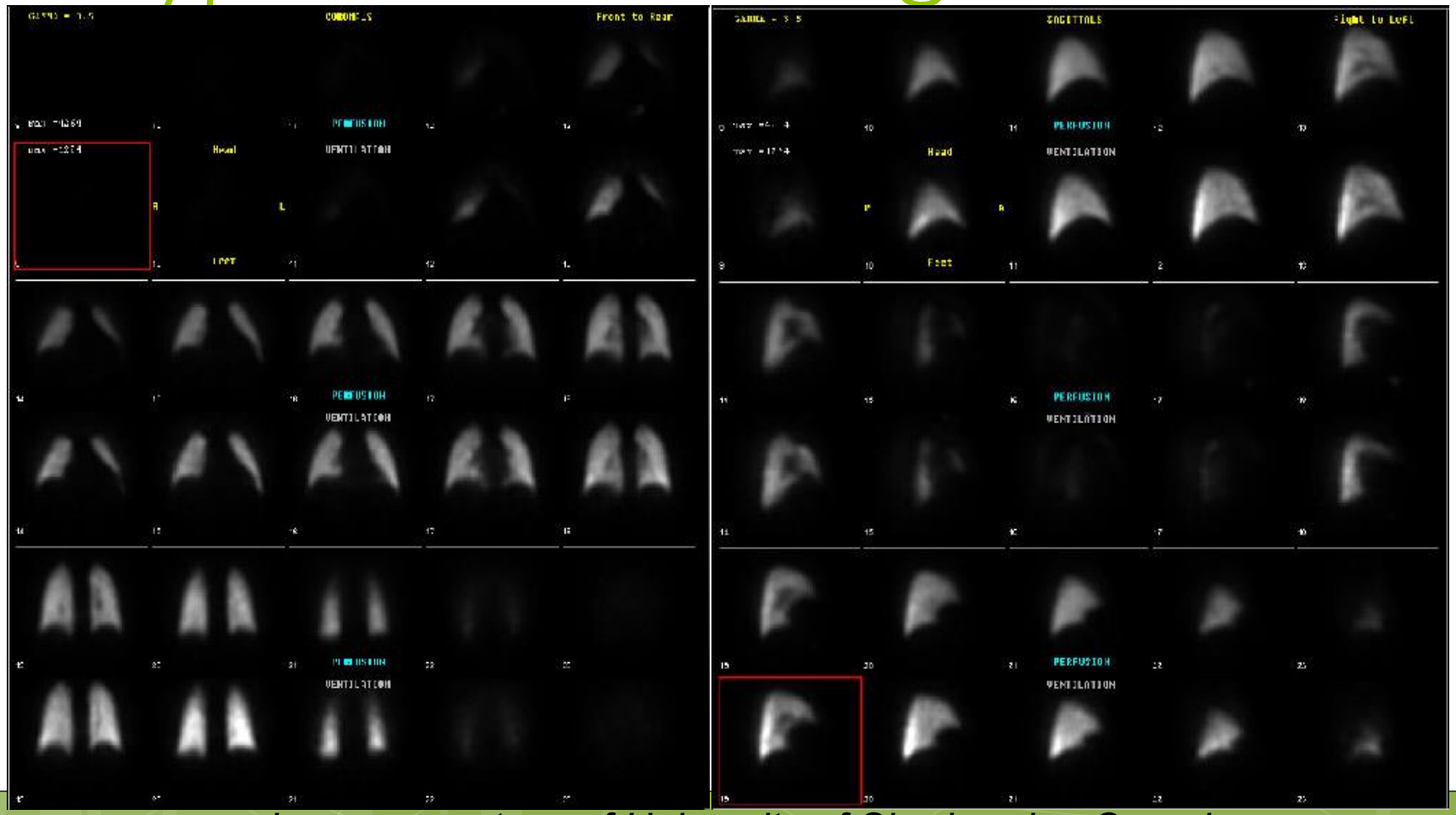
Technegas-Image Acquistion

- Essentially the same as Tc99m aerosols
- Can do planar imaging, 200K per view, 8 views are typically acquired (ant, lao, llat, lpo, post, rpo, rlat, rao)
- However, SPECT is now the standard

VQ SPECT Acquisition

- Ventilation: takes approx. 10min
- Perfusion: takes approx. 15min
  - 60views, 6 degrees/step
  - 15sec/frame (vent)
  - 25sec/frame (perf)
  - Matrix 128x128
  - Zoom 1.0
  - Step and shoot or continuous acquisition
  - Can use either filtered back projection, or OSEM/LMEM for reconstruction(GE InfiniaHE4)

Typical SPECT images:



Images courtesy of University of Sherbrooke, Canada

Tips for success:

- The key to success in acquiring SPECT lung scans is to have a good ventilation.
- Ensure that you have adequate counts in the lungs to produce high image quality.
- Remember the count rate differential between ventilation and perfusion images is ideally 3-4 times higher for perfusion

Tips for success with Technegas

- Ensure patients take a full breath but not a bigger breath than they are normally accustomed to taking
- Breath hold is important to allow the lungs to absorb the technegas
- Once the patient has breathed an adequate amount of technegas have the patient breathe a couple of more breaths through the PAS to ensure residual technegas is trapped in the PAS and does not contaminate the room

Technegas and Isotope Shortages

- There is no minimum amount of activity that must be loaded into the crucibles. During times of shortage, smaller amounts of activity can be used, and the crucibles can be loaded several times to ensure adequate dosage for the patient.
- Simmer plates and crucible ovens can also be used to allow pre-simmering of multiple crucibles.

Resources:

- Special thanks to Lynn McLauchlin from Cyclomedica Canada for Technegas information and slides.
- SNM guidelines: SNM Practice Guideline for Lung Scintigraphy 4.0

Thank You!