Considering Thallium (Tl)-201 SPECT MPI

Starting in 2009, a global shortage limited the availability of technetium (Tc)-99m, a widely used radiotracer for single-photon emission computed tomography (SPECT) myocardial perfusion imaging (MPI). While that shortage has since eased somewhat, many nuclear labs still consider using thallium (Tl)-201 protocols for SPECT MPI. Overall, Tl-201 represents an acceptable alternative to Tc-99m, if labs make the necessary adjustments in terms of training, accreditation, equipment, and patient scheduling and care.

Tl-201 is an analog of potassium with a physical half-life of 73 hours, high first-pass extraction, rapid clearance from the intravascular space, and redistribution that begins 10 to 15 minutes after injection.[1] These characteristics make Tl-201 useful for assessing both myocardial blood flow and the viability of myocardial tissue; however, there are some disadvantages, such as somewhat poorer image quality and increased radiation burden.

Tl-201 PROTOCOLS

The most common Tl-201 SPECT MPI protocol is stress/redistribution with optional reinjection.[1] Tl-201 is injected just prior to peak exercise stress or at peak pharmacologic stress, and images are acquired 10 to 15 minutes later.[1] A redistribution (rest) study is then performed 2.5 to 4 hours later. If the images show a fixed defect, another redistribution study may be acquired at 18 to 24 hours to give a clearer determination of whether the defect is truly fixed or if the tissue is still viable.[1] It is particularly important to determine the viability of a fixed defect if the patient has had a previous myocardial infarction (MI).[2] Another option to assess viability is to reinject with 1-2 mCi Tl-201 immediately after the first redistribution study, and then acquire another image.[1] This allows the protocol to be completed in 1 day, but exposes the patient to a higher radiation dosage.

The dual-isotope protocol uses a small quantity of Tc-99m for the stress image and Tl-201 for the rest image.[1] This protocol may help conserve existing supplies of Tc-99m, and it takes advantage of the favorable properties of each tracer—blood flow assessment with Tc-99m and viability assessment with Tl-201.[3] Imaging in this manner provides valuable information on viability, particularly for patients with previous MI or heart failure.[1] Again, however, the radiation burden to the patient is substantially higher with dual isotope than with Tc-99m protocols.

CAMERA PARAMETERS

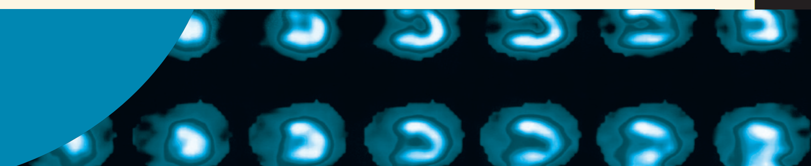
Labs that usually use Tc-99m will need to make some adjustments to their camera parameters in order to perform Tl-201 SPECT MPI. The best Tl-201 images are usually achieved using a low-energy all-purpose (LEAP) SPECT collimator, as opposed to the low-energy high-resolution (LEHR) collimator used with Tc-99m.[4] Some older labs may have both collimators on hand, in which case they can simply be switched out for Tl-201 studies. LEHR collimators can still be used, but time per projection must be increased.[5] In addition, Tl-201 images require more filtering. Scanner configuration, reconstruction algorithms, radionuclide doses, and patient populations vary between laboratories,[4] so each lab should select camera parameters in consultation with the interpreting physician. Table 1 lists the optimum camera parameters for the Tl-201 stress/redistribution protocol.[4] Tl-201 produces lower counts and has a higher incidence of tissue attenuation, and thus more scatter radiation.[4] For these reasons, images generally will not be as clear as those of Tc-99m, and may require readjustment by the reading physician.

Table 1. Camera parameters for stress/redistribution Tl-201 acquisition.

Parameter	Stress study	Redistribution (rest) study	Guideline
Dose	2.5-3.5 mCi Tl-201	Not applicable	Standard
Position	Supine	Same	Standard
	Prone	Same	Optional
	Upright/Semiupright	Same	Optional
Delay time (Injection → imaging)	10-15 minutes[a]	Not applicable	Standard
Delay time (Stress → rest)	Not applicable	3-4 hours	Standard
Energy windows	30% symmetric, 70 keV 20% symmetric, 167 keV	Same	Standard
Collimator	LEAP	Same	Preferred
Orbit	180° (45° RAO to 45° LPO)	Same	Preferred
Orbit type	Circular	Same	Standard
	Noncircular	Same	Standard
Pixel size	6.4 ± 0.4 mm	Same	Standard
Acquisition type	Step and shoot	Same	Standard
	Continuous	Same	Optional
Number of projections	32-64	Same	Standard
Matrix	64 x 64	Same	Standard
Time/projection	40 s (32 fr), 25 s (64 fr)	Same	Standard

RAO=right anterior oblique; LPO=left posterior oblique

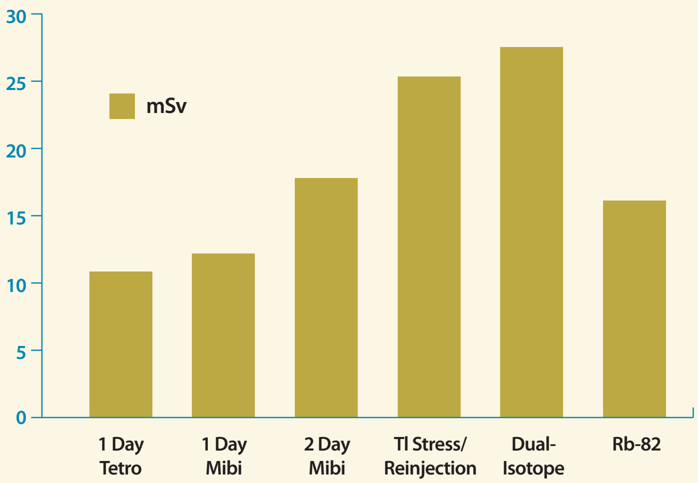
[a] An anterior planar image may be acquired during this interval to evaluate Tl-201 lung uptake.



LOGISTICS AND SCHEDULING

Switching to Tl-201 will also require changes to scheduling and office logistics. Because Tl-201 images must be acquired 10 to 15 minutes after injection,[1] patients will need to be injected in close proximity to the scanner. A delay of at least 10 minutes is required to avoid upward-creep artifacts, which can lead to false-positive findings.[5] Scheduling will need to account for the fact that there is no "lag time" between injection and imaging, as there is with Tc-99m. In addition, the redistribution study is performed 2.5 to 4 hours later, and there may be a reinjection image performed that day, or another redistribution image performed the following day.

Figure 1. Patient radiation exposure from various MPI protocols.



Adapted from Thompson R, et al. *J Nucl Cardiol.* 2006;13:19-23.

RADIATION EXPOSURE

As mentioned earlier, the major drawback to Tl-201 SPECT MPI is the increased radiation burden. The dual-isotope protocol gives an approximate patient radiation dosage of 27.3 mSv, the highest among common cardiovascular radionuclide imaging studies.[6] The Tl-201 stress/redistribution/reinjection protocol is almost as high, at 25.1 mSv.[6] In comparison, the 3 most common Tc-99m protocols have dosages of 10.6 mSv, 12 mSv, and 17.5 mSv (see Figure 1).[6]

TRAINING AND ACCREDITATION

To perform Tl-201 SPECT protocols, a nuclear lab's US Nuclear Regulatory Commission (NRC) or Agreement State license must include the Tl-201 radiotracer, or be a broad scope license.[7] Otherwise, the license will need to be amended.[8] In addition, the American College of Radiology (ACR) accreditation requires that each SPECT scanner be accredited for each isotope to be used on that scanner.[9]

If a lab is currently accredited with the Intersocietal Accreditation Commission (IAC) Nuclear/PET and has the proper license, switching to Tl-201 protocols should have very little effect on lab accreditation. Although most US nuclear labs stopped using Tl-201 after Tc-99m–labeled sestamibi was approved by the Food and Drug Administration in 1991,[10] nuclear cardiologists, nurses, and technologists should have had some general background training based on appropriate reading and review of case files, in the absence of hands-on experience with Tl-201 SPECT MPI.[11] To ensure that a lab is accredited by IAC Nuclear/PET to perform Tl-201 imaging, the Medical Director is required to create a written protocol detailing how the lab will image with Tl-201 prior to performing the first study.[12] The protocol should be in compliance with guidelines published by professional societies. Labs are not required to submit that protocol to the IAC Nuclear/PET—they are only required to have it available.[13]

ISSUES RELATED TO LONGER HALF-LIFE

Due to its longer half-life, it will take longer for stored Tl-201 to decay to background levels than Tc-99m. Labs should check with their NRC or Agreement State regulations regarding the disposal of nuclear waste in their jurisdiction. In addition, Tl-201 may remain detectable in the body for up to 30 days postinjection, so patients who will be traveling after receiving Tl-201 SPECT MPI may need a note from the lab explaining their unusually high radiation levels.[14]

CONCLUSIONS

During periodic global Tc-99m shortages, many nuclear labs have considered the use of Tl-201 for SPECT MPI. Tl-201 protocols provide valuable data on myocardial blood flow and viability, though with higher radiation dosage and somewhat lower-quality images. Camera parameters, logistics, and scheduling in the nuclear lab will likely need to change to accommodate Tl-201. As long as the proper license is held, maintaining IAC Nuclear/PET accreditation with Tl-201 should not be difficult. Tl-201 protocols are an acceptable alternative to Tc-99m.

For more information on Tl-201, visit the following Web sites:

ASNC – Tl-201, Guidelines, and Standards
http://www.asnc.org/content_184.cfm?navID=73

ASNC – Resources and Educational Programs
http://www.asnc.org/content_550.cfm

NRC – Licensing
http://www.nrc.gov/materials/medical.html

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