

REVIEW ARTICLE—EDUCATIONAL TRACK

Gamma Camera Testing Schedules for Nuclear Cardiology Facilities

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Abstract

Interpreting medical scans acquired with nuclear imaging equipment requires testing the equipment to assure that the best results achievable are routinely and reliably produced. Strict adherence to predetermined schedules for testing and recording the results for gamma cameras will facilitate the efficient operation of a Nuclear Cardiology laboratory, satisfy regulatory and accreditation requirements, and instill confidence in the readings obtained by interpreting the collected patient scans, for the ultimate benefit of the patients being evaluated.

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Interpreting medical scans acquired with nuclear imaging equipment requires testing the equipment to assure that the best results achievable are routinely and reliably produced. Laboratory accrediting agencies and insurance companies expect records to be maintained of the results of equipment testing and the steps taken to remedy uncovered problems (1). Guidance regarding the types of tests that should be performed, and the schedule with which these tests should be conducted, can be obtained through the web sites of the American Association of Physicists in Medicine (2), the American College of Radiology (3), the Intersocietal Accreditation Commission (4), and the Joint Commission for the Accreditation of Hospital Organizations (1).

To detect problems before they result in inadequate or compromised imaging studies, strict adherence to predetermined testing schedules is recommended. Based on the frequencies which with most Anger camera problems have been observed to occur, these tests are broken down into those recommended to be performed on a daily, weekly, monthly and quarterly basis (Table 1). The service representatives for the imaging equipment should be contacted immediately in the event of the failure of any of these tests, and the equipment should not be used until the source of a problem is identified and resolved and successful test results are obtained and

documented. In addition, annual quality assurance (QA) equipment checks are performed that go beyond the less frequently performed tests (Table 2).

Planar gamma cameras

Planar systems require daily tests to verify that the equipment can be correctly peaked for the energies of the isotopes that are commonly used for a specific camera. Flood field uniformity must be assessed either intrinsically (without a collimator) using ^{99m}Tc or extrinsically (with the collimators in place) using a Co-57 sheet source. Equipment manufacturers specify upper limits of useful field of view and central field of view non-uniform contrast associated with these tests. Following the successful completion of these daily QA tests, a recommended practice is to verify that detectors are on the correct energy peak individually for each patient using the activity injected in the patient for the radioactivity source just prior to beginning data collection.

Weekly QA tests for planar gamma cameras involve acquiring bar phantom images (Table 1), either intrinsically or extrinsically. Most commonly, quadrant phantoms are used for this purpose. Each week a quadrant phantom is rotated so that the smallest bars are imaged in each of the 4 quadrants of the detectors over the course of one month.

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Table 1 Schedule for planar and gamma camera tests

Testing Frequency	Planar cameras	SPECT systems
Daily		
- Energy peaking	X	X
- Intrinsic floods	X	X
- (Daily attenuation correction QA tests)		(X)
Weekly		
- Planar spatial resolution using bar phantoms	X	
Weekly - to - Monthly		
- Center of Rotation		X
- High count extrinsic floods		X
- (Weekly attenuation correction QA tests)		(X)
Quarterly		
- Multi-purpose plastic (e.g. Jaszczak) phantoms		X
- Tomographic resolution (line source or point source)		X

Table 2 Annual nuclear laboratory equipment tests

Testing Description	Planar cameras	SPECT systems
1) Intrinsic integral & differential uniformity of all used isotopes	X	X
2) ^{99m} Tc intrinsic spatial resolution	X	X
3) ^{99m} Tc energy resolution	X	X
4) Count rate parameters; ^{99m} Tc intrinsic maximum count rate capability	X	X
5) System Co-57 & LEHR extrinsic uniformity	X	X
6) Relative sensitivity; Co-57 & LEHR count rate per unit activity	X	X
7) Overall System performance for SPECT Systems		X
8) Formatter/video display	X	X
9) System interlocks	X	X
10) Thyroid uptake unit tests	-	-
11) Activity calibrator tests	-	-
12) Radiation survey monitoring equipment	-	-

SPECT

The most common types of SPECT systems in widespread use are rotating planar Anger cameras. These systems require regular updates of the center-of-rotation correction information. Depending on the recommendations of the equipment manufacturer, these procedures may be performed by technologists on a weekly basis (Table 1), or may be performed less frequently by camera service engineers. This refers to the information provided to the data collection computer about the direction in space in which detectors are aimed when they are at any given projection angle. Failure to correctly handle this information will cause what should be point sources to be mapped incorrectly into tuning fork shaped objects for 180° scans or into donuts for 360° degree scan, either of which can cause imaging artifacts that are particularly serious for myocardial perfusion scans, as these often will manifest as perfusion defects, even in patients with normal

myocardial perfusion (5).

While daily flood fields often are acquired for 3 million counts, which can provide flood fields that appear to be sufficiently uniform to the casual observer, tolerances of flood field non-uniformities are more stringent for detectors used for SPECT systems than for those only used for planar imaging. Consequently, higher numbers of counts (typically 100–120 million counts) must be collected. Some manufacturers recommend this be done weekly and provide the means for technologists to perform these updated high count corrections (Table 1), while other manufacturers stipulate that monthly-to-quarterly updates will suffice and that these should be performed only by their camera service personnel. Failure to correct tomograms with adequately high count information can result in concentric ring artifacts that can interfere with image interpretation. Similar artifacts can be caused by a mistuned detector (5). Whether technologists perform the

center of rotation and high count extrinsic flood field corrections themselves, or instead rely on the manufacturers' camera service personnel to perform these tasks, it is important for them to be familiar with these tests and the implications of corrections potentially being inadequate or out of date, so as to facilitate the recognition of imaging artifacts and the process of correcting these if they are detected.

Quarterly QA tests of SPECT systems consist of acquiring three-dimensional phantom images (Table 1). A commonly used phantom for this purpose is a "Jaszczak phantom" (Data Spectrum Corp, NC) (6), which consists of a cylindrical water bath with solid rod and solid sphere inserts, into which radioactivity is loaded. This affords evaluation of tomographic contrast through the section passing through solid spheres, an approximate evaluation of tomographic spatial resolution through the section passing through rods, and uniformity of response by examining the section passing through the uniform section of the phantom. Appearance of concentric ring artifacts passing through this uniform section indicates inadequacy of sufficiently uniform flood field corrections of the detectors.

Another quarterly test verifies optimal SPECT system tomographic spatial resolution. This consists of forming a count profile through the tomogram of a reconstructed point source. The spatial resolution of this count profile (full width at half maximum) should agree to within 10% with a similar measurement for a planar image of the same point source acquired for the same number of counts positioned at the same distance from the collimator (5).

Two-detector systems are the most prevalent configuration of multi-detector SPECT systems, which are particularly well suited to cardiac imaging. Detector tests need to be performed separately for each detector of a multi-detector rotating SPECT system.

Further considerations

CT components of SPECT/CT systems require their own QA tests (2), which should be performed in accordance with manufacturer's instructions and following a schedule consistent with accrediting agency guidelines (3). Regardless of the methods used for attenuation correction, when transmission scans are used to produce transmission maps for attenuation correction these systems must also be evaluated (Table 1). Each manufacturer has their own tests and required frequency.

Non-rotating systems, including those that use CZT and other solid state detectors, require specialized procedures and

specialized phantoms designed specifically for their use (4).

Additional annual tests, such as those mandated by some of the accrediting organizations (3), verify proper functioning of gantry interlocks and image displays, as well as tests of non-imaging radiation equipment, including radiation survey meters and activity calibrators (Table 2).

Conclusions

Strict adherence to predetermined schedules for testing and recording the results for gamma cameras will facilitate the efficient operation of a Nuclear Cardiology laboratory, satisfy regulatory and accreditation requirements, and instill confidence in the readings obtained by interpreting the collected patient scans, for the ultimate benefit to the health and safety of the patients being evaluated.

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Conflicts of interests

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