New and Innovative CZT-based Gamma Cameras

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CZT Detectors
- Dual detector planar imaging
  - Molecular Breast Imaging
- 12- Detector SPECT/CT Imaging
  - Veriton (spectrum Dynamics)
  - Starguide (GE – not FDA approved)

Imaging the breast with conventional Gamma Camera
- Large detector designed for imaging the whole body
- Only front and side views of the breast can be obtained
- Poor resolution - cannot reliably detect tumors < 15 mm in diameter
Molecular Breast Imaging (MBI)

• Excellent Intrinsic Resolution = 1.6 mm / 2.5 mm
• No dead space – ideal for breast imaging

Test Equipment Frequency Acquisition Details Passing Criteria

<table>
<thead>
<tr>
<th>Test</th>
<th>Equipment</th>
<th>Frequency</th>
<th>Acquisition details</th>
<th>Passing criteria</th>
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<tbody>
<tr>
<td>Uniformity</td>
<td>Co-57 sheet source or fillable phantom</td>
<td>Daily</td>
<td>7.5 Mcts</td>
<td>≤ 5% integral uniformity</td>
</tr>
<tr>
<td>Spatial Resolution</td>
<td>4-quadrant bar phantom</td>
<td>Semi-annually</td>
<td>7.5 Mcts; phantom angle across FOV</td>
<td>Meets manufacturer’s specifications ≤ 10% difference between 2 detectors</td>
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<tr>
<td>Sensitivity</td>
<td>Flask</td>
<td>Annually</td>
<td>120 second images</td>
<td></td>
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<tr>
<td>Energy Resolution</td>
<td>Point source</td>
<td>Annually</td>
<td>2 keV energy window; 1 minute images</td>
<td>Meets manufacturer’s specifications. FWHM ≤ 6%</td>
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<tr>
<td>Contrast/Clearance Test</td>
<td>Contrast detail phantom</td>
<td>Quarterly</td>
<td>9 Mcts; Images at 3 depths</td>
<td>CNR ≥ 3/ counted number of visible lesions at each depth</td>
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Clinical Images required for ACR

Currently we submit MBI images under the heading of hepatobiliary images, as no MBI category exists.

MBI vs Conventional Gamma Camera
Differences in testing and QC

Spatial Resolution: Not really required for a pixelated system. If performed, rotate the bar ~45 degrees to reduce aliasing artifacts.

The ACR Subcommittee on Nuclear Medicine Physics recommends the following:

The weekly resolution phantom is not necessary on cameras with pixelated detectors but a resolution image using either the ACR DIRECT phantom (preferred) or a 4-quadrant bar phantom must be done at least semi-annually and also submitted with the accreditation testing materials.
MBI vs Conventional Gamma Camera
Differences in testing and QC

System sensitivity:
The flask should be filled completely with water and Tc-99m to minimize differences between detector geometry. Both images can be acquired simultaneously.

Difference in sensitivity < 10%

Jaszczak phantom:
Separation between detectors insufficient to allow Jaszczak phantom to be placed in the field of view.

Alternative option - Contrast Detail phantom

D. Dickerscheid, et al,
Contrast-noise-ratio (CNR) analysis and optimization of breast-specific gamma imaging (BSGI) acquisition protocols,

Sample contrast detail phantom images acquired at distances of 1.5 cm, 3.0 cm and 4.5 cm, respectively, from collimator face.
ACR Accreditation of MBI Units
(similar to what was done for BSGI systems)

Next Generation SPECT/CT Imaging
Veriton (Spectrum Dynamics)
Starguide (GE Healthcare)

Conventional Dual-detector SPECT/CT
Veriton SPECT/CT

12 independent detectors equipped with tungsten collimators
Each detector = 4 x 32 cm FOV
Detectors move in a radial direction
Each detector can swiveled over a 180° arc.
The gantry has a rotational range of 25°
Current detectors capable of imaging up to ~200 keV

Angular scan range of motion of each detector is selectable.
12 independent detectors equipped with tungsten collimators
Each detector = 4 x 32 cm FOV
Detectors move in a radial direction
Each detector can swivel over a 180° arc.
The gantry has a rotational range of 45°
Current detectors capable of imaging up to ~200 keV

Angular scan range of motion of each detector is selectable.
Short angular range used for imaging small organs / head

QC / Acceptance Testing on Veriton / Starguide

Key points to note:
In terms of QC and testing, the Veriton has more in common with a conventional PET/CT system than with a conventional SPECT/CT system.

The Veriton cannot perform planar imaging (although pseudo-planar images can be produced from the tomographic data if needed)

The majority of acceptance testing procedures that are routinely performed on conventional SPECT/CT systems, cannot be performed on the Veriton or Starguide systems.

Vendors supply a suite of QC tools specifically designed for these systems.
QC / Acceptance Testing on Veriton / Starguide

Co-57 rod source (12 mCi) in position

Daily Quality Control – Veriton System:
- Uniformity
- Sensitivity
- Energy peaking / resolution
- Detector registration (equivalent to COR check)

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**RESULTS**

- **Total Counts:** 801,150
- **Acquisition Time:** 04:22
- **Regional Homogeneity Index:** 98%
- **Global Homogeneity Index:** 96.71%
- **Effective FOV:** 99.63%
- **Scan Sensitivity:** 2,581 cpm/mC

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**Energy Peaking**

- **Energy Windows:** 15.63 %
- **Energy Resolution:** 5.98 %

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**Detector Registration**

- **Registration Index:** 99.36 %
Jaszczak phantom

QC / Acceptance Testing on Veriton / Starguide
Conventional SPECT/CT
Veriton – Phantom
suspended in air (OSEM Recon)

ACR accreditation

Because many of the standard QC measurements cannot be performed, a letter clarifying why these tests were not performed was submitted along with the accreditation documentation.

This is similar to what was done when we applied for accreditation of the D-SPECT system.
Summary:

• Many of the QC and acceptance test procedures used for conventional sodium iodide based gamma cameras are not longer applicable to the next generation of semi-conductor based gamma camera systems.

• The ACR currently makes an exception for these systems in its accreditation process

• As systems such as the Veriton and Starguide become more widely utilized, new standards and procedures need to be developed for testing and QC of these devices.