Breast Imaging using Tc99m-Sestamibi: Can lower doses be used for Breast-Specific Gamma Imaging (BSGI)/Molecular Breast Imaging (MBI)?

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Purpose

The Tc99m-Sestamibi drug package insert recommends 740 - 1110 MBq dose for breast imaging however this dose was established using standard gamma cameras. There are now several breast-optimized gamma cameras available with up to 4 times higher photon sensitivity. This study is designed to investigate if there are physiologic limitations to reducing the dose by comparing breast tissue uptake of Sestamibi at a standard 740 MBq dose to that at lower doses.

Methods and Materials

Patients scheduled for breast scintigraphy were imaged using a Dilon 6800 Gamma Camera following the SNM Practice Guidelines for Breast Scintigraphy (2010). Each had a standard 740 MBq dose separated into 2 syringes containing either two 370 MBq doses or a 185 and a 555 MBq dose. Each syringe activity was measured immediately prior to injection. Subjects were randomized into receiving fractional doses of 185 (n=18), 370 (n=20) or 555 (n=22) MBq followed by bilateral CC acquisitions. Then the remaining fraction of the 740 MBq dose was delivered and a normal 4-view imaging procedure was conducted. An ROI encompassing the breast was drawn in each CC image and the average number of counts per pixel (ACP) was calculated. Following correction of the ACP values for radioisotope decay and biological washout (described by Del Vecchio et al, J Nucl Med 1997; 38:1348-51), the ACP of the first (low dose) image was expressed as a percentage of the ACP of the 740 Mbq image for each breast). The left and right breast percentages were averaged and compared to the activity of the first injected dose expressed as a percentage of the total injected dose.

Results

Results for the 60 of the 66 patients recruited have been analyzed. For the first injected doses of 185 MBq, 370 MBq, and 555 MBq, the average difference between the injected dose ratio and the measured uptake ratio was 0.55%, 0.03%, and 1.09%, respectively. Given the null hypothesis of equal ratios, the two-tailed t-test p values for these differences were 0.58, 0.98, and 0.38, respectively. It should be noted that this correlation reflects a correction for radioactive decay and the expected tissue washout as modeled by Del Vecchio, et al resulting in an effective half-life of 134 minutes. In addition, there is a relatively broad distribution of uptake (SD = 38%) around the mean value.
Fig. 1: A BSGI image with the ROIs used to determine the photon density. This case shows the 370 MBq images on the top and the 740 MBq images below.
**Fig. 2:** Figure 2 illustrates the mean image photon density compared to the mean injected dose for each of the dose groups. There is excellent agreement between the two values only after corrections have been made for decay and tissue washout. Note the broad distribution of the photon density above and below the mean values.

<table>
<thead>
<tr>
<th></th>
<th>Administered Dose</th>
<th>TEDE (mSv) (Whole Body)</th>
<th>Dose to Breast Tissue (mSv)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Screening MMG 4 view only</td>
<td>n/a</td>
<td>0.44 - 0.7</td>
<td>0.4 – 0.7</td>
</tr>
<tr>
<td>Diagnostic MMG</td>
<td>n/a</td>
<td>0.4 – 1.3</td>
<td>0.4 – 1.3</td>
</tr>
<tr>
<td>BSGI/MBI</td>
<td>259 - 740 MBq</td>
<td>2.1 - 5.9</td>
<td>0.07 - 0.2</td>
</tr>
<tr>
<td>CT chest</td>
<td>N/A</td>
<td>7.8</td>
<td>2.4</td>
</tr>
<tr>
<td>Coronary CT (Women)</td>
<td>N/A</td>
<td>10.2</td>
<td>3.5</td>
</tr>
<tr>
<td>PET (F-18 FDG)</td>
<td>370 MBq</td>
<td>7.2</td>
<td>0.3</td>
</tr>
<tr>
<td>CT abdomen and pelvis</td>
<td>N/A</td>
<td>14.7</td>
<td>0.08</td>
</tr>
<tr>
<td>PET/CT</td>
<td>185 – 370 MBq</td>
<td>10.0 - 23.0</td>
<td>2.7</td>
</tr>
</tbody>
</table>

**Fig. 3:** The radiation dose from BSGI conducted at various dose levels compared to other common radiologic procedures.
Conclusion

These preliminary results suggest the uptake of Sestamibi in breast tissue is relatively proportional to the injected dose and therefore, it should be possible to improve image quality in terms of signal-to-noise ratio (S:N) using the new breast-optimized detector systems. The detector efficiency improvements found with the such systems open two options for the clinician. The first option is to maintain the 740 MBq (20 mCi) dose injection and imaging time to improve the S:N, which should result in improved sensitivity for small, low-contrast lesions while the second option would be to reduce either the dose or imaging time and obtain a S:N ratio similar to that from the standard gamma camera images.

However, if the clinical protocol is modified for low-dose imaging, it is important to keep in mind two factors. First, there is broad interpatient variance in breast tissue uptake of MIBI resulting in an Standard Deviation of +/- 38% around the mean value. Therefore the dose selected needs to be sufficient to ensure good image quality for patients at the lower end of the uptake range or the clinical protocol needs to ensure that longer imaging time is used for these cases. In addition, the effective half-life of MIBI in the breast tissue is approximately 134 minutes and therefore the protocol should ensure a dose-to-imaging time of no greater than 10 minutes in order to ensure image quality.

References

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