MOLECULAR BREAST IMAGING: ADMINISTERED ACTIVITY DOES NOT REQUIRE ADJUSTMENT BASED ON PATIENT SIZE

Thuy D. Tran¹, CNMT
Lacey R. Ellingson¹, CNMT
Tiffinee N. Swanson¹, CNMT
Courtney M. Solberg¹, CNMT
Michael K. O’Connor¹, PhD
Carrie B. Hruska¹, PhD
Department of Radiology¹
Mayo Clinic, Rochester, MN

Correspondence Author:
Carrie B. Hruska, Ph.D.
Department of Radiology
Mayo Clinic
200 First Street SW
Rochester, MN 55905-0001
Phone: 507-293-4719 Fax: 507-266-4461
hruska.carrie@mayo.edu

First Author:
Thuy D. Tran, CNMT
Department of Radiology
Mayo Clinic
200 First Street SW
Rochester, MN 55905-0001
Phone: 507-293-3964 Fax: (507) 266-4461
tran.duong@mayo.edu

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Short running title: Dose Regimen in MBI is Not Weight Based
Abstract

Objective: At our institution, MBI is performed with 300 MBq $^{99m}$Tc sestamibi for all patients. For some nuclear medicine procedures, administered activity or imaging time is increased for patients of larger size in order to obtain adequate counts. Our objective was to assess whether uptake of $^{99m}$Tc sestamibi in the breast is influenced by patient size. Methods: Records from patients who underwent a clinical MBI examination between July – November 2016 were reviewed. Those in whom our standard injection and preparation techniques were followed were included in the analysis [3,4]. Patients were injected with approximately 300 MBq $^{99m}$Tc sestamibi. Residual activity was measured to allow calculation of exact administered activity for each patient. Breast images were acquired at 10 min/view using a dual-head CZT-based gamma camera [5]. Breast thickness was measured as the distance between the two detectors. Patient height, weight, body surface area and body mass index were obtained from records. Lean body mass with the James equation (LBMJames) and Janmahasatian correction (LBMJanma) was calculated as described in [6]. Count density in the breast tissue was measured by drawing a region of interest around the central breast tissue of the right breast mediolateral-oblique view of the lower detector. Count density was expressed as cts/cm$^2$/MBq administered activity. Spearman’s correlation coefficient ($r_s$) was calculated. Results: A total of 200 patients were analyzed. No dose infiltration was suspected at any injection. Average administered activity was 292 MBq (s.d. = 13.8 MBq; range 247 – 326 MBq). Average count density was 7.2 cts/cm$^2$/MBq (s.d. = 2.7 cts/cm$^2$/MBq; range 3.1 – 17.8 cts/cm$^2$/MBq). MBI count density was weakly negatively correlated with height ($r_s = -0.18; p=0.01$), weight ($r_s = -0.23; p=<0.001$), body mass index ($r_s = -0.16; p=0.02$), body surface area ($r_s = -0.22; p=0.002$), LBMJames ($r_s = -0.23; p=0.001$), and LBMJanma ($r_s = -0.23; p=0.001$). No correlation was observed between count density and breast thickness ($r_s=0.06; p=0.37$). Conclusion: Our results suggest a lack of relationship between uptake of $^{99m}$Tc sestamibi in breast tissue and body size or compressed breast thickness. Altering from the standard 300 MBq administered activity for larger patients is likely unnecessary.
INTRODUCTION

Molecular breast imaging (MBI) is a low-dose nuclear medicine test that uses dedicated semiconductor-based gamma cameras and injection of a radiotracer, primarily $^{99m}$Tc sestamibi, to examine functional behavior of breast tissue (1). MBI has shown utility as a supplemental screening tool for detecting mammographically-occult breast cancers in women with dense breast tissue (1).

In the last few years, efforts to standardize MBI examinations have focused on several factors which influence uptake of $^{99m}$Tc sestamibi in the breast tissue. In one study, patients were asked to exercise on a treadmill during injection; this practice was found to have the undesired effect of decreasing sestamibi uptake in the breast tissue (2). A study of the effects of caffeine intake showed it had no effect on sestamibi uptake (2). However, the combination of the following three methods was shown to increase sestamibi uptake in the breast tissue by ~50%: patient fasting prior to injection, placing a warm blanket around the patient prior to injection, and using a syringe known to provide minimum residual activity for dose injections (2,3). Although these measures were found to help improve uptake in the breast tissue, count density was still highly variable among patients (2), suggesting that further investigation of other factors influencing sestamibi uptake in the breast tissue is warranted.

As fasting, warming and the use of low adhesion syringes are now part of our standardized MBI practice, a closer look at the impact of patient size on $^{99m}$Tc sestamibi uptake in the breast tissue is necessary. For some nuclear medicine procedures, administered activity or imaging time is increased for patients of larger body habitus in order to obtain adequate image counts. For example, according to the American Society of Nuclear Cardiology (ASNC) Stress...
Protocol Guidelines, increased administered activity should be considered for patients weighing over 250 pounds undergoing myocardial perfusion imaging to achieve sufficient count statistics in image quality (4). The purpose of this study was to evaluate the effects of patient size on sestamibi uptake in breast tissue under optimal patient preparation and determine if weight-based administered activity should be used in MBI examinations.

**MATERIALS AND METHODS**

Retrospective analysis of patient records was conducted under a minimum-risk IRB-approved and HIPAA compliant research protocol. Records from patients who underwent a clinical MBI examination between July and November of 2016 were reviewed. Patients who followed the standard injection and preparation techniques as described below were included in the analysis (2,3). Patients with breast implants were excluded from this analysis.

MBI examinations were performed using a dedicated dual-head cadmium zinc telluride (CZT) based gamma camera optimized for low-dose imaging (LumaGem, Gamma Medica, Salem, NH, USA) (4). Prior to the injection of $^{99m}$Tc sestamibi, patients fasted for a minimum of 3 hours. A warm blanket was placed around the patient’s shoulders and chest for approximately 5 minutes prior to injection to facilitate peripheral blood flow and increase uptake of $^{99m}$Tc sestamibi in the breast tissue(2). After explanation of exam, patients were injected with approximately 300 MBq $^{99m}$Tc sestamibi using a syringe known to provide low adhesion of sestamibi(3). The radiotracer was administered intravenously to the patient’s arm or hand using a butterfly needle or indwelling catheter followed by a 10-mL saline flush. Pre-injection activity, time of injection, and post-injection residual activity were measured to allow calculation of exact administered activity for each patient.
Patient positioning and imaging began immediately post-injection. Bilateral craniocaudal and mediolateral-oblique views were acquired for 10 minutes per view using standard mammographic positioning techniques. Light compression was applied to the breast to limit patient motion, and breast thickness was recorded as the distance between the two detectors. Patient height, weight, body surface area and body mass index were extracted from records closest to the date of MBI examination (median time from MBI = 2 days; IQR 0 to 53 days). In addition, lean body mass was calculated using the James (LBM\textsubscript{James}) and Janmahasatian (LBM\textsubscript{Janma}) equations specific to women in estimating patient’s body weight minus adipose tissue (5).

The right breast mediolateral-oblique view of the lower detector for each patient was used for count density analysis. Using in-house image analysis software, the count density in the breast tissue was measured by drawing a region of interest around the central breast tissue excluding the pectoral muscle, any lesions and edges of the detector (Figure 1). Count density was expressed as cts/cm\textsuperscript{2}/MBq administered activity. The relationship between count density and patient body size factors was assessed with Spearman’s correlation coefficient (\(r_s\)). A p-value of less than 0.05 was considered significant.

RESULTS

A total of 200 patients were analyzed. No dose infiltration was suspected at any injection. Average age of the study group was 57 yrs (s.d. = 9.7 yrs, range 35 to 86 yrs). The average administered activity, calculated after accounting for residual activity, was 292 MBq (s.d. = 13.8 MBq; range 247 – 326 MBq). The average count density on MBI was 7.2 cts/cm\textsuperscript{2}/MBq (s.d. = 2.7 cts/cm\textsuperscript{2}/MBq; range 3.1 – 17.8 cts/cm\textsuperscript{2}/MBq).
As given in Table 1, MBI count density was weakly negatively correlated with height, weight, body mass index, body surface area, LBM_{James}, and LBM_{Janma} (all p< 0.02). No correlation was observed between count density and breast thickness (p=0.37).

DISCUSSION

The results of this study reveal that patient size characteristics do not significantly influence uptake of $^{99m}$Tc sestamibi in breast tissue. Despite all patients following standardized patient preparation and injection procedures, we did not observe a consistent relationship between count density and patient size factors based on height and weight or breast thickness. These findings are in contrast to other nuclear medicine publications indicating a weight-based dose regimen to be beneficial in improving image quality(6). A wide range of count densities on MBI was observed in this cohort (3.1 – 17.8 cts/cm$^2$/MBq), suggesting that other factors not accounted for in this study (i.e. liver function or inherent mitochondrial activity of breast tissue) influence sestamibi uptake in breast tissue.

There were some limitations in the design of this study. The patient’s fasting status at the time of injection was patient-reported and not verified through quantitative means such as glucose testing. It is possible that some patients may not have strictly followed fasting instructions, which may influence the uptake in breast tissue. Also, as shown in a previous study, light to moderate exercise performed at the time of injection decreases sestamibi uptake in the breast tissue as uptake is increased in muscle tissue elsewhere in the body. Patients were not asked if they had completed an exercise workout prior to their MBI exam. It is possible that the residual effects of a workout could impact the distribution of sestamibi in the body. However, these results reflect the findings that would be observed in a typical clinical practice setting.
CONCLUSIONS

Our results showed either a very weak or lack of relationship between uptake of $^{99m}$Tc sestamibi in breast tissue and patient size factors including height, weight, body mass index, body surface area, lean body mass, and compressed breast thickness. Altering from the standard 300 MBq administered activity based on patient size is likely unnecessary for MBI examinations.
References


Figure 1: region of interest of the right mediolateral - oblique view of the lower detector
Figure 2: Relationship between count density and patient size factors. Scatter plot shows the relationship between count density and patient weight (A), patient BMI (B), height (C), body surface area (D), breast thickness (E), Lean Body Mass (F, G)

$r_s = -0.23$

$P \leq 0.001$
$r_s = 0.16$

$P = 0.02$
$r_s = -0.18$
$P = 0.01$
$r_s = -0.22$
$P = 0.002$
$r_s = -0.06$

$P = 0.37$
$r_s = -0.23$

$P = 0.001$
$r_s = -0.23$
$P = 0.001$
### Table 1: Correlation between Count Density and Patient Characteristics

<table>
<thead>
<tr>
<th>Patient Characteristic</th>
<th>$r_s$</th>
<th>P-value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Weight</td>
<td>-0.23</td>
<td>&lt;0.001</td>
</tr>
<tr>
<td>Height</td>
<td>-0.18</td>
<td>0.01</td>
</tr>
<tr>
<td>Body mass index</td>
<td>-0.16</td>
<td>0.02</td>
</tr>
<tr>
<td>Body surface area</td>
<td>-0.22</td>
<td>0.002</td>
</tr>
<tr>
<td>LBMJames</td>
<td>-0.23</td>
<td>0.001</td>
</tr>
<tr>
<td>LBMJanma</td>
<td>-0.23</td>
<td>0.001</td>
</tr>
<tr>
<td>Breast thickness</td>
<td>0.06</td>
<td>0.37</td>
</tr>
</tbody>
</table>

Spearman’s rho ($r_s$) = < 0.19 (very weak), 0.20 – 0.39 (weak), 0.40 – 0.59 (moderate), 0.60 – 0.79 (strong), 0.80 – 1.0 (very strong)