Breast Model Validation for Monte Carlo Evaluation of Normalized Glandular Dose Coefficients in Mammography

A. Sarno, G. Mettivier, F. Di Lillo, K. Bliznakova, I. Sechopoulos and P. Russo

Napoli, 17th October 2017

sarno@na.infn.it
Dosimetry in mammography

Mean Glandular Dose (MGD) = DgN (or c·g·s) · K

Air kerma at the breast surface

Coefficients calculated via MC simulations
Breast model assumptions: skin thickness

<table>
<thead>
<tr>
<th>Model from</th>
<th>Skin layer (mm)</th>
<th>Adipose layer (mm)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Dance (1990)</td>
<td>0.00</td>
<td>5.00</td>
</tr>
<tr>
<td>Wu et al (1991)</td>
<td>4.00</td>
<td>0.00</td>
</tr>
<tr>
<td>BCT experiments</td>
<td>1.45</td>
<td>0.00</td>
</tr>
<tr>
<td>Histology</td>
<td>1.45</td>
<td>2.00</td>
</tr>
</tbody>
</table>
Breast model assumptions: glandular distribution

\[ \text{Probability of dose absorption in the gland} = \frac{f_g \times \mu_{\text{en}}}{\rho} (E)_g }{ f_g \times \mu_{\text{en}}/(E)_g + (1 - f_g) \times \mu_{\text{en}}/(E)_a } \]
MC code for breast dosimetry

Code based on GEANT4 toolkit

Physics list: Option4

Code validated vs AAPM TG195 data

![](chart.png)
20 voxelized patient specific breast phantoms from 3D breast images

MC validation for the heterogeneous model

Homogeneous vs. heterogeneous breast model

Breast thickness = 5 cm
20% glandular

100*(MGD_{homo} - MGD_{hete})/MGD_{homo}

Incident photon energy, $E$ (keV)
Skin thickness influence on the MGD

Compressed breast thickness = 5 cm; glandular fraction = 20%
Skin model influence on the MGD

Compressed breast thickness = 5 cm; glandular fraction = 20%
Standard models vs. patient specific phantoms

- Dance model
- Wu et al model

W/Al 0.7 mm
kVp tuned on the breast thickness

Mean = 0.89
Median
Mean = 1.01

- 75th percentile
- 25th percentile
- 10th percentile
- Max
- 90th percentile

Model - to - patient specific MGD

MGD ratio

Max

W/Al 0.7 mm
kVp tuned on the breast thickness

Mean = 1.01

Min
New models vs. patient specific phantoms

Model - to - patient specific MGD

Mean = 1.01
Mean = 0.98
Max
90th percentile
75th percentile
Median
25th percentile
10th percentile
Min

W/Al 0.7 mm
kVp tuned on the breast thickness

1.45 mm skin
1.45 mm skin + 2 mm fat

MGD ratio
Conclusions

- The skin model in MC simulations presents a large influence on MGD estimates;
- A simple breast model can produce MGD underestimation up to about 40\% when compared to the dose estimates via patient specific breast phantoms;
- The model proposed by Wu et al (1991) led to the lowest dose overestimation (18\%) combined with the highest MGD underestimation (-40\%) for a specific breast;
- Breast model with a 1.45 mm skin thickness and the Dance’s model led to the lowest differences (1\%), on average, when compared to patient specific breast phantoms, with respect to Wu’s model (-11\%).
Thank you!!!

Any questions?

International Conference on Monte Carlo Techniques for Medical Application (MCMA2017) - Napoli 15th-18th October 2017

sarno@na.infn.it