

Glandular Dose in Digital Mammography: Monte Carlo method using voxel phantom

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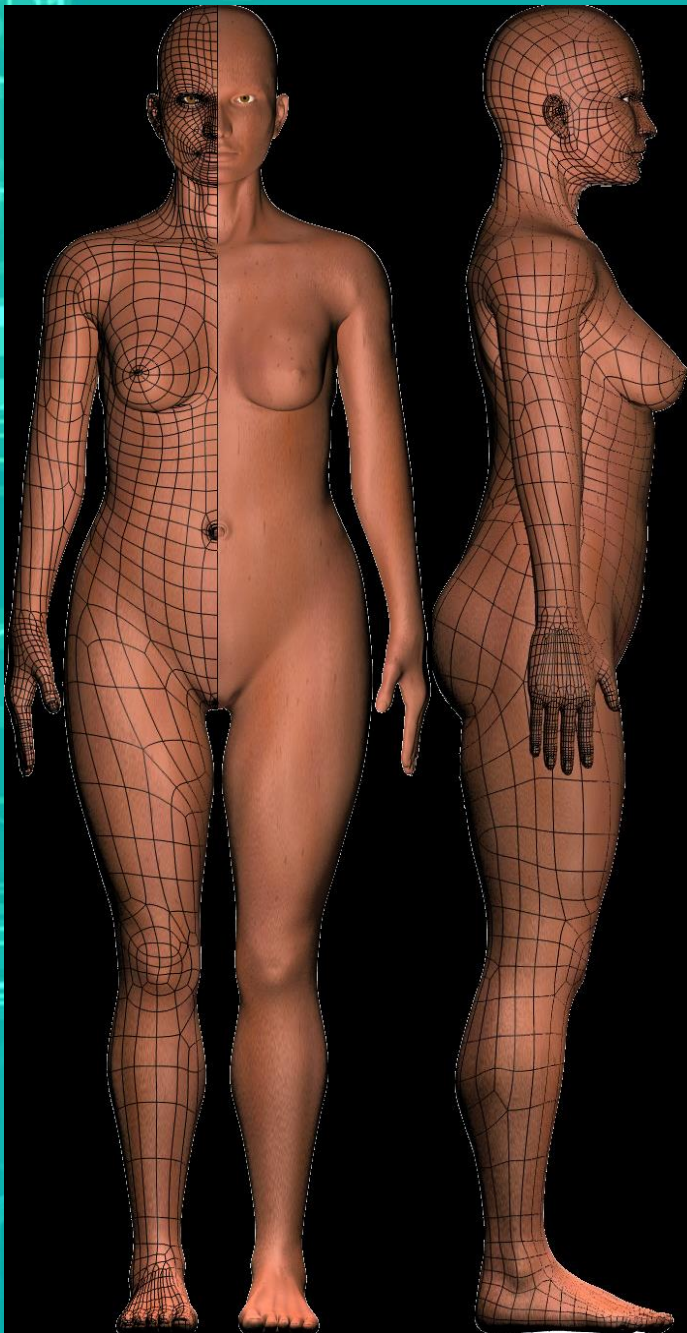
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Introduction

In breast, the glandular tissues are of high sensitivity to radiation and for this reason the mean dose to the glandular tissues is the most suitable dosimetric quantity. According to the IAEA protocols the Mean Glandular Dose (MGD) is derived from measurements of the incident Air Kerma at the surface of phantom and of the HVL, using tabulated conversion coefficients. Disadvantage of the method is the fact that for calculations use a very simple model of the breast.



Voxel Phantom

Purpose

The purpose of this study is to assess the mean glandular dose in breast using Monte Carlo code and voxel phantoms in standing posture.

Simple geometrical model of the breast used previously for calculation of the MGD.



Mixed adipose and glandular tissue

Adipose tissue

Materials and Methods

- Fifty different phantoms (breast's thickness from 2 to 8 cm for both CC and MLO modes and for glandular fractions in the range of 1% – 100%) and EGSnrc Monte Carlo code was used to calculate the interaction of photons with matter and estimate the MGD to the breast. The calculations were made for the x-ray spectra from a Rh target (tube voltage range 26-32 kV) filtered by Rh.

Results

For breast phantoms of 2.0-8.0 cm thick and 1%-100% glandular fraction CC view acquisitions can result in a MGD of 0.752 – 4.101 mGy. MGD is decreased with increasing glandularities and with increasing breast thickness in general.

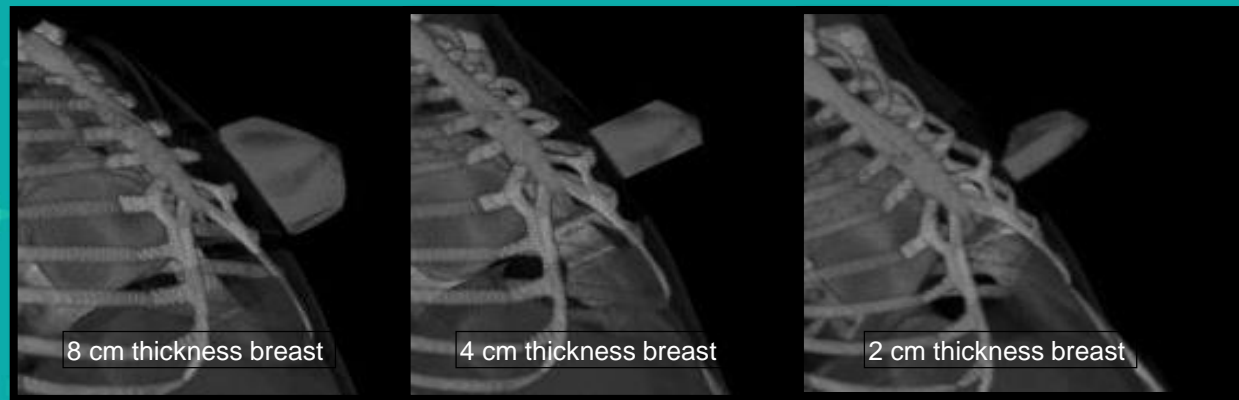


Figure 1: Three-dimensional distributions of glandular tissue within the breast for different thickness breast.

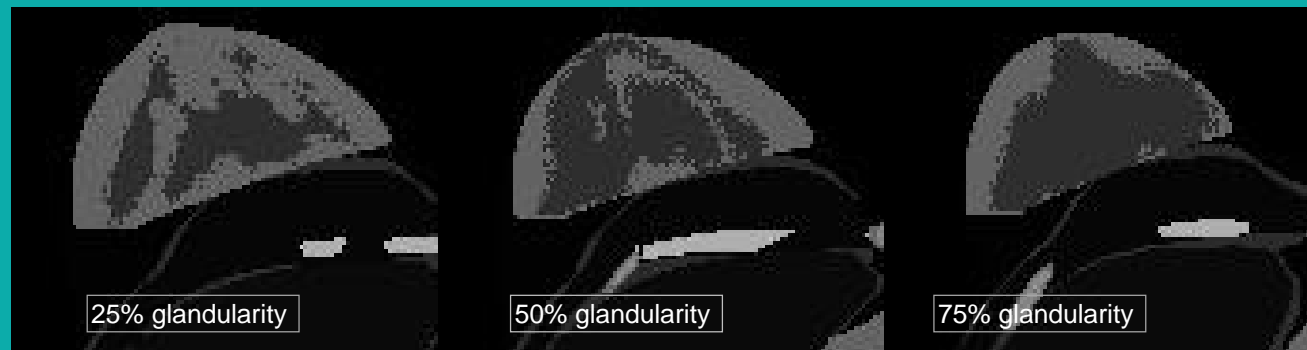


Figure 2: Horizontal slices through 5 cm breasts voxel phantoms with 25%, 50%, 75% glandularity.

Results

Monte Carlo Results for Mean Glandular Dose

kV	GI'ty %	2cm	4cm	5cm	6cm	8cm
26	1	1.56E+00	9.34E-01	8.32E-01	3.27E-01	3.22E-01
26	25	1.47E+00	9.14E-01	8.06E-01	6.07E-01	3.59E-01
26	50	1.33E+00	8.14E-01	7.12E-01	5.71E-01	3.77E-01
26	75	1.24E+00	7.53E-01	6.58E-01	5.51E-01	4.07E-01
26	100	1.26E+00	7.52E-01	6.64E-01	5.61E-01	4.27E-01
28	1	2.04E+00	1.34E+00	1.21E+00	5.58E-01	5.50E-01
28	25	1.92E+00	1.29E+00	1.16E+00	9.18E-01	5.88E-01
28	50	1.75E+00	1.16E+00	1.04E+00	8.48E-01	6.05E-01
28	75	1.64E+00	1.07E+00	9.57E-01	8.09E-01	6.30E-01
28	100	1.67E+00	1.07E+00	9.61E-01	8.22E-01	6.56E-01
30	1	2.36E+00	1.62E+00	1.47E+00	7.24E-01	6.99E-01
30	25	2.21E+00	1.55E+00	1.40E+00	1.12E+00	7.50E-01
30	50	2.04E+00	1.38E+00	1.24E+00	1.04E+00	7.64E-01
30	75	1.91E+00	1.28E+00	1.15E+00	9.86E-01	7.79E-01
30	100	1.96E+00	1.29E+00	1.16E+00	9.96E-01	8.08E-01
32	1	2.54E+00	1.80E+00	1.63E+00	8.28E-01	8.09E-01
32	25	2.42E+00	1.71E+00	1.56E+00	1.26E+00	8.66E-01
32	50	2.22E+00	1.54E+00	1.39E+00	1.17E+00	8.69E-01
32	75	2.09E+00	1.42E+00	1.28E+00	1.10E+00	8.86E-01
32	100	2.13E+00	1.43E+00	1.29E+00	1.12E+00	9.15E-01

Note.-Data are normalized MGD (in mGy per mGy of Air Kerma).

Results

Calculated Results for Mean Glandular Dose

Breast Thickness (cm)	1% Glandular Fraction	25% Glandular Fraction	50% Glandular Fraction	75% Glandular Fraction	100% Glandular Fraction
2	0.752	0.885	1.024	1.072	1.215
4	1.027	1.272	1.261	1.309	1.460
5	1.144	1.410	1.413	1.468	1.633
6	1.372	1.669	1.752	1.842	2.084
8	2.030	2.754	3.114	3.572	4.101

Note.-Data are MGD (in mGy).

- The results of this study were compared with Dance's results. Significant differences have been found between the normalized glandular dose obtained by this study and the conversion factor g , from work of Dance et al. For the cases considered, the differences can be as large as 34% due to many factors. The normalized glandular dose was calculated for the whole region of the irradiated breast and not just for the central area. In this study the term 'glandularity' refers to the fraction by voxel of glandular and adipose tissue within the whole breast, rather than the fraction by weight of glandular and ductal tissues within the central region of the breast.

Conclusions

Measurements of air kerma and the EGSnrc Monte Carlo code were employed to estimate the mean glandular dose in voxel phantom, which is a powerful tool for the study of breast dosimetry. If the distribution of glandular tissue within the breast is known, the results of this study can be used to provide an estimated mean glandular dose for individual cases.