Monte Carlo Calculation of Normalized Glandular Dose in Mammography

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Introduction:

To get the dose evaluation in mammography be executed more easily, Monte Carlo simulation (EGS4-LSCAT) is utilized to calculate normalized glandular dose for mammographic x-ray spectra of wide ranges. Normalized glandular dose is just mean glandular dose, which is the most relevant indicator of risk in mammography, normalized to entrance surface dose. Clinically, entrance surface dose can be measured easily and mean glandular dose comes out after entrance surface dose being multiplied by normalized glandular dose. This study aims to establish a table of normalized glandular dose for different beam qualities (different half-value layers).

Material and Methods:

We followed NIST to set 5 beam qualities with Mo anode and Mo filters of different thicknesses (half value layer: 0.282 mm Al, 0.302 mm Al, 0.342 mm Al, 0.358 mm Al, 0.389 mm Al) and measured each spectrum at the National Radiation Standard Laboratory (NRSL) in the Institute of Nuclear Energy Research. These spectra were used in computation of normalized glandular dose. A simple test of calculation of normalized acrylic phantom dose was carried out first. Normalized acrylic phantom dose was assumed to be the 5 cm depth dose of a cubic acrylic phantom normalized to the entrance surface dose. Agreement was obtained from measured the normalized phantom doses and the computed ones. Thus, agreement was also obtained for more difficult tasks- calculations of normalized glandular dose. The average glandular dose and the entrance surface dose measured by an ion chamber could be simulated by the Monte Carlo method. Program settings: Several cylinders and plates were combined to become a breast, compression paddles, and an ion chamber. One piece of compression paddle is upon the breast and the other piece is under the breast. Both compression paddles were 0.3 cm thick. The breast had a central region which was composed of a 50:50 mixture by weight adipose and glandular tissues and an outer shield region of adipose tissue 0.5 cm thick. The whole breast thickness was from 3 to 6 cm. The ion chamber was set to be a flat cavity ion chamber (ion chamber for mammography) with 3 cc active volume.

Results:

Normalized glandular dose increased with the beam half value layer but decreased with breast thickness. The outcome was compared with normalized glandular dose calculated by Dance, and they had the same trend. Irradiation fields of different sizes made difference in calculation of normalized glandular dose. The larger the field was, the bigger the normalized glandular dose.

Conclusion:

Monte Carlo is a good method to evaluate the mean glandular dose that cannot be measured directly. Besides the breast thickness or beam half value layers, other factors also affect the glandular dose like breast composition and size of compression paddles. We will test all items and establish the complete tabulation of normalized glandular dose with various ways in the future.