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Quantifying MGD in Heterogeneous Breast Phantoms for Synchrotron Phase Contrast CT- A Simulation-Based Study

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With clinical breast imaging trials soon taking place at the Australian Synchrotron using phase contrast CT, accurately characterising the radiation dose, specifically the Mean Glandular Dose (MGD), is essential for ensuring radiation safety and optimising beam parameters. A GEANT4 simulation study was performed to investigate the effects of beam energies, 32 keV and 35 keV, on anthropomorphic breast phantoms. These phantoms, representing different breast cup sizes ranging from A to D, were modelled as homogeneous and heterogeneous distributions with 30% glanduarity. The heterogeneous phantoms had glandular tissue embedded within adipose tissue, consisting of 30% of the breast volume, to simulate realistic tissue distribution. To comply with the 4mGy dose limit for breast imaging, exposure times were calculated. For homogeneous breast models, safe exposure times ranged from (43 ± 7) seconds at 32 keV to (33 ± 4) seconds at 35 keV, depending on breast size. In the heterogeneous models, individualised glandular distributions led to higher MGD, requiring shorter exposure times to stay within safety limits. Importantly, when the dose was determined using a homogeneous breast tissue distribution and compared to that of a heterogeneous model, the resulting MGD was found to be approximately 30% higher, indicating a potential overestimation of patient dose if homogeneity is assumed in clinical assessments. This highlights the need to incorporate realistic tissue distributions in clinical practice to avoid overestimating patient dose and optimise exposure parameters.

Author: MATHARU, Tavjot Kaur (University of Wollongong)

Co-authors: ROSENFELD, Anatoly (University of Wollongong); Dr CUTAJAR, Dean (University of Wollongong); Dr ENGELS, Elette (University of Wollongong); LERCH, Michael (University of Wollongong)

Presenter: MATHARU, Tavjot Kaur (University of Wollongong)

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