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Computational anthropometric pregnant female phantom library for fetal dose assessment in occupational radiation exposures

Due to the high radio-sensitivity of the fetus, the accurate estimation of fetal organ dose and its radiation risk assessment are crucial for radiation protection for pregnant females in occupational radiation exposures. Computational phantoms have been widely used in radiation dosimetry while their reliability strongly depends on the anatomical description and physiological characterization of represented subjects. In this work, we aim to build the first phantom library for pregnant females and fetuses for more reliable and accurate radiation dosimetry for pregnant workers.

Materials and Methods: Computed tomography (CT) images of the abdominal and pelvic regions of 46 pregnant females were segmented by experienced medical physicists. The segmented tissues / organs include the body contour, skeleton, uterus, liver, kidney, intestine, stomach, lung, bladder, gall bladder, spleen and pancreas for maternal body, and placenta, amniotic fluid, fetal body, fetal brain and fetal skeletons for the conceptus. The Non-Uniform Rational B-Splines (NURBS) surface of each identified region was constructed manually in 3D modeling software. The Hounsfield unit (HU) values of each identified organs were measured in the CT images and converted into the tissue density. The organ volume was further adjusted according to the reference measurements for developing fetus recommended by World Health Organization (WHO) and International Commission on Radiological Protection (ICRP). A series of anatomical parameters, including femur length (FL), humerus length (HL), biparietal diameter (BPD), abdominal circumference (FAC) and head circumference (HC), were measured and compared with WHO recommendations.

Results: The first phantom library for pregnant workers was established while the anatomical parameters of each model consist with the selected individuals with gestational age varying from 8-weeks to 35-weeks.

Conclusions: The constructed anthropometric computational models are consistent with those of the corresponding individuals. The resulting virtual pregnant females can be used in radiation dosimetry studies to improve the reliability of fetal organ dose and radiation risk assessment. The easiness of deformation and displacement of NURBS surface also makes the studies of understanding the effect of maternal postures, fetal postures and positions on radiation dose calculations convenient.

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