# Development and Evaluation of a New Algorithm for Determining Radiation Dose to the Red Bone Marrow

by

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## ABSTRACT

Red bone marrow is among the tissues of the human body that are most sensitive to ionizing radiation. Red bone marrow cannot be easily modeled because it is distributed heterogeneously throughout the skeleton and cannot be distinguished from yellow or inactive bone marrow by radiographic means, so dosimetry models must apply algorithms to estimate the dose to the red bone marrow. The current methods for deriving red bone marrow distribution from CT data are based on assumptions that may not be anatomically realistic and the uncertainty of such calculations has been difficult to estimate. This dissertation describes a new algorithm for calculating the distribution of red bone marrow and the applications of the algorithm. The CT data and red bone marrow distribution algorithms are incorporated into an EGS4 user code to assess the effects of the red bone marrow distribution on the computed dose to the red bone marrow for three irradiation scenarios. Parallel beams of monoenergetic photons have been modeled from the Anterior-Posterior, Posterior-Anterior, Left Lateral and Right Lateral directions in the energy range of 30 keV to 6 MeV. Monoenergetic photons in the range of 30 keV to 1 MeV have been modeled in geometries representing head and abdominal CT examinations. A so-called "whole body irradiation" procedure for a 6-direction 3.9 MeV electron protocol has also been studied. Comparing the whole body red bone marrow doses for these irradiations demonstrates a discrepancy between the two different methods for parallel beams of photons below about 200 keV as high as 25%. At higher energies, the disparity in red bone marrow dose is less than 5%. For non-uniform irradiations, however, a greater improvement is realized with the proposed new method. An improvement in red bone marrow dose of 25% to 35% was found for the CT examinations, and nearly 40% for the whole body electron skin treatment protocol. The data presented here justify the need to better understand the uncertainty in existing dosimetry methodologies for radiation protection. This dissertation also presents recommendations for incorporating the new algorithm into other models and for future work.