Validation of Proposed Revisions to ICRP Human Respiratory Tract Model Using Bioassay Data Associated with an Acute Inhalation of Refractory PuO_2

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The International Commission on Radiological Protection (ICRP) is currently in the process of updating its biokinetic and dosimetric models, including the Human Respiratory Tract Model (HRTM). In order to account for the observed long-term retention of insoluble material in the lungs, Gregoratto et al. proposed a physiologically-based particle transport model that significantly simplifies the representation of particle clearance from alveolar-interstitial (AI) region. In proposed revision to the HRTM, the material deposited in the AI region is partitioned into just two clearance pathways: an "alveolar" compartment (A) is cleared only to the bronchioles and an "interstitial" compartment (I) is cleared only to the thoracic lymph nodes. This model was applied to the extensive bioassay data from the U.S. Transuranium and Uranium Registries' (USTUR) tissue donors exposed to Refractory PuO_2 during the 1965 plutonium fire accident at the Rocky Flats Plant. Case 0202 and Case 0407 are the two highest exposed of 18 USTUR tissue donors involved in this accident. The respiratory tract of the registrant 0202 was most likely compromised by his prior occupational exposure to coal dust, smoking habit and chronic obstructive pulmonary disease, while donor 0407 was a non-smoker and had no prior history of lung disorder. Bayesian analysis using the Weighted Likelihood Monte-Carlo Sampling (WeLMoS) method was performed in order to calculate the posterior probability distributions of critical model parameter values and dose estimates directly from the respective sets of bioassay and tissue analysis data. Similarities in and differences between the results for these two cases are discussed. It is demonstrated that, with appropriate adjustments, the simplified particle transport model proposed by Gregoratto et al. results in an acceptable fit to both USTUR data sets. The results of the study support the hypothesis that the PuO_2 particles produced by the fire are extremely insoluble, with less than 1% absorbed relatively rapidly (at a rate of about 2 d^{-1}) while the remainder is absorbed very slowly (at a rate of about 5×10^{-6} d^{-1} or less). Hence, the recommended dose coefficient for type S plutonium significantly underestimates the lung doses for this type of material.

USTUR-0310A-11