Bayesian Analysis of Bioassay and Autopsy Data from 18-y Follow-up of an Acute Accidental Inhalation of Refractory PuO_2

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The International Commission on Radiological Protection (ICRP) is currently reviewing and updating its biokinetic and dosimetric models, including the Human Respiratory Tract Model (HRTM) recommended in Publication 66 (1994). It is important to test and verify proposed changes to the HRTM against available human data for various intake scenarios. Case 0202 was the highest exposed of 18 USTUR Registrant tissue donors involved in the 1965 Pu fire accident at the Rocky Flats Plant (RFP). This study analyzed the extensive bioassay data (RFP counts of ^{241}Am activity in the lungs and urinary excretion of plutonium through 8 y after intake) and radiochemical analysis of plutonium and americium in tissues sampled at autopsy (18 y after intake) to evaluate the applicability of the current ICRP Human Respiratory Tract Model and a proposed revision to represent these data. It was demonstrated that substantial revision of the HRTM structure and particle transport parameter values are needed to represent the exceptionally long retention of plutonium particles in the lungs observed in this case. Particle transport from the AI region to the bronchioles occurred in two distinct phases: about 20% of the initial alveolar deposition was cleared at a rate of about 0.007 d^{-1} (half-time of about 100 d) and about 80% was cleared extremely slowly (at a net rate of about 3×10^{-5} d^{-1}; half-time about 60 y). About ⅓ of this material was cleared to the bronchioles and ⅔ to the thoracic lymph nodes. With appropriate adjustments of AI deposition fractionation and associated particle transport rates, the simplified particle transport model derived recently by Gregoratto et al. yielded an excellent fit to all of the Case 0202 data. The PuO_2 particles produced by the plutonium fire are extremely insoluble. About 0.6% of $^{238/239}$Pu is absorbed from the respiratory tract relatively rapidly, at a rate of about 2 d^{-1} (half-time about 8 h). The remainder (99.4%) is absorbed extremely slowly, at a rate of about 5×10^{-6} d^{-1} (half-time about 400 y). For this form of plutonium, doses to other body organs are negligible in comparison to those to tissues of the respiratory tract. About 97% of the total committed weighted dose equivalent is contributed by the lungs. The committed weighted dose equivalent per unit intake (from inhaled $^{239/240}$Pu) is about 9×10^{-5} Sv Bq^{-1}. This is an order of magnitude higher than the recommended dose coefficient for Type S plutonium (8.4×10^{-6}). Bayesian analysis was used to calculate the posterior probability distributions of critical parameter values for the different particle transport models tested, directly from the case data (with appropriate prior assumptions). The doses absorbed by this worker's lungs were high (3 Gy to his alveolar-interstitial tissue and 6 Gy

to his thoracic lymph nodes). His prior occupational exposure to coal dust (and prior lung disease) are likely to have impaired lung clearance in this case, and thus contributed to this worker's high lung tissue doses.

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