The Development of the Plutonium Lung Clearance Model for Exposure Estimation of the MAYAK Production Association, Nuclear Plant Workers

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The purpose of this study was to develop a biokinetic model that uses urinary plutonium excretion rate data to estimate the plutonium accumulation in the human respiratory tract after occupational exposure. The model is based on autopsy and urinalysis data, specifically the plutonium distribution between the respiratory tract and the remainder of the body, taken from 543 former workers of a radiochemical facility at the Mayak Production association (MPA) plant. The metabolism of plutonium was represented with a compartmental model, which considers individual exposure histories an the inherent solubility properties of industrial plutonium aerosols. The transport properties of plutonium-containing aerosols were estimated by experimentally defining their in vitro solubility. The in vitro solubilities were found by dialysis in a ringer's solution. Analysis of the autopsy data indicated that a considerable fraction of the inhaled plutonium is systemically redistributed rapidly after inhalation. After the initial dynamic period, a three-compartment model describes the retention in the lungs, the second compartment describes a plutonium lung concentration in the pulmonary lymph nodes. The model parameters were estimated by minimizing sum squared of the error between the tissue and bioassay data and the model results. The parameters reflect the inverse relationship between plutonium retention in lungs and the experimentally derived aerosol transportability. The model was validated by comparing the autopsy results with in vivo data for 347 cases. The validation indicates that the model parameters are unbiased. This model is being used to estimate individual levels of nuclide accumulation and to compute radiation doses based upon the urinary excretion rates.

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