Modeling Uranium Hexafluoride Inhalation

Maia Avtandilashvili[1], Matthew Puncher[2], Stacey L. McComish[1], and Sergei Y. Tolmachev[1]

[1]United States Transuranium and Uranium Registries, College of Pharmacy, Washington State University, Richland, WA 99354, USA; [2]Department of Toxicology, Centre for Radiation, Chemical and Environmental Hazards, Public Health England, Chilton, Didcot, Oxon, OX11 0RQ, UK

The U.S. Transuranium and Uranium Registries' whole-body donor (Case 1031) was exposed to a single acute inhalation of uranium hexafluoride (UF_6) produced from an explosion at a processing facility. Inductively coupled plasma mass-spectrometric analysis of tissue samples collected at the autopsy 65 y after the accident indicated unusually long-term retention of inhaled slightly-enriched uranium material (0.85% ^{235}U) in the deep lungs and thoracic lymph nodes inconsistent with the International Commission on Radiological Protection (ICRP) human respiratory tract model predictions for soluble uranium compounds. The tissue measurement and bioassay monitoring data from this case were analyzed with the ICRP biokinetic models using both conventional (maximum likelihood) and Bayesian statistical analysis methods. Maximum likelihood analysis using the current ICRP human respiratory tract model resulted in an estimated intake of 79 mg of uranium composed of 86% soluble, Type F material and 14% insoluble, Type S material. For the Bayesian approach, the Markov Chain Monte Carlo (MCMC) method was applied to the data to estimate posterior probability distributions of intake and case-specific lung model parameters, using the revised human respiratory tract model that is being used by ICRP to calculate revised effective dose coefficients for workers. The MCMC results were fairly consistent with the maximum likelihood analysis, supporting the fact that the inhaled uranium material was predominantly Type F with a small but significant Type S component: 95% posterior ranges of the rapid fraction and slow dissolution rate were 0.12-0.91, and 0.00022-0.00036 d^{-1} with the median values at 0.37 and 0.00031 d^{-1}, respectively. The derived posterior distributions of dissolution parameter values were used to calculate the corresponding 95% range of effective dose per unit intake of uranium resulting from inhalation of the UF_6 mixture. It was demonstrated that the ICRP effective dose coefficient recommended for UF_6 was located below the lower 2.5%-quantile of this range. Hence, the use of the dissolution parameter values obtained here may be more appropriate for radiation protection purposes when individuals are exposed to a UF6 mixture that contains an insoluble uranium component.

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