US Transuranium and Uranium Registries Case Study on Accidental Exposure to Uranium Hexafluoride

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The United States Transuranium and Uranium Registries' (USTUR) whole-body donor (Case 1031) was exposed to an acute inhalation of uranium hexafluoride (UF_6) produced from an explosion at a uranium processing plant 65 years prior to his death. The USTUR measurements of tissue samples collected at the autopsy indicated long-term retention of inhaled slightly enriched uranium material (0.85% ^{235}U) in the deep lungs and thoracic lymph nodes. In the present study, the authors combined the tissue measurement results with historical bioassay data, and analysed them with International Commission on Radiological Protection (ICRP) respiratory tract models and the ICRP Publication 69 systemic model for uranium using maximum likelihood and Bayesian statistical methods. The purpose of the analysis was to estimate intakes and model parameter values that best describe the data, and evaluate their effect on dose assessment. The maximum likelihood analysis, which used the ICRP Publication 66 human respiratory tract model, resulted in a point estimate of 79 mg of uranium for the occupational intake composed of 86% soluble, type F material and 14% insoluble, type S material. For the Bayesian approach, the authors applied the Markov Chain Monte Carlo method, but this time used the revised human respiratory tract model, which is currently being used by ICRP to calculate new dose coefficients for workers. The Bayesian analysis estimated that the mean uranium intake was 160 mg, and calculated the case-specific lung dissolution parameters with their associated uncertainties. The parameters were consistent with the inhaled uranium material being predominantly soluble with a small but significant insoluble component. The 95% posterior range of the rapid dissolution fraction (the fraction of deposited material that is absorbed to blood rapidly) was 0.12 to 0.91 with a median of 0.37. The remaining fraction was absorbed slowly, with a 95% range of 0.00022 d^{-1} to 0.00036 d^{-1} and a median of 0.00031 d^{-1}. The effective dose per unit intake calculated using the dissolution parameters derived from the maximum likelihood and the Bayesian analyses was higher than the current ICRP dose coefficient for type F uranium by a factor of 2 or 7, respectively; the higher value of the latter was due to use of the revised respiratory tract model. The dissolution parameter values obtained here may be more appropriate to use for radiation protection purposes when individuals are exposed to a UF_6 mixture that contains an insoluble uranium component.

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