Uncertainty Analysis on Organ Activities and Intakes from Occupational Exposure to Plutonium

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The United States Transuranium and Uranium Registries (USTUR) studies the actinide biokinetics and tissue dosimetry in accidentally exposed nuclear workers (volunteer tissue donors). Since 1968, the USTUR has received 313 partial- and 47 whole-body tissue donations. Post-mortem radiochemical analyses of tissues collected at autopsy provide information on long-term retention and distribution of actinides in the human body. These data are accompanied by workers' detailed records on exposure incidents, bioassay monitoring, and medical history. These datasets provide a unique opportunity to evaluate uncertainties in the radiation dose assessment for radiation epidemiology. Among 349 cases with completed radiochemical analysis, 55 cases were selected based on the following criteria: a) at least, five Pu-239 urine measurements exceeding the contemporary detection limit; b) Pu-239 concentrations in the skeleton and liver greater than 0.1 Bq/kg and 1 Bq/kg, respectively, and c) no extensive decorporation therapy. The objectives of this study were to compare: 1) Pu-239 activities in the skeleton and liver predicted based upon urine bioassay with activities measured post-mortem; 2) intake estimates based on the urine data alone with those based on both urine data and post-mortem radiochemical analyses. IMBA Professional Plus® internal dosimetry software was used to fit the super complex intake regime and to predict organ activity using the ICRP 130 Human Respiratory Tract, ICRP 141 Plutonium Systemic, and ICRP 30 Gatro-Intestinal Tract models. Investigation of 11 individuals, who had worked at the same worksite revealed that the model predictions of Pu-239 activities in organs estimated from urine bioassay differed from the measured values, on average, by 16±36% for the skeleton, and 10±78% for the liver. Intakes calculated using urine data alone differed from those estimated by simultaneously fitting the urine and tissue radiochemical analysis data, on average, by 98±107%.

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