Biokinetics of Highly Enriched Uranium in a Female Nuclear Worker

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A female whole-body donor to the United States Transuranium and Uranium Registries (USTUR), Case 1028, was employed at a nuclear defense facility for 27 years and was exposed to enriched uranium (EU) via inhalation. Extensive bioassay data including urine and chest measurements were available from worksite records. Worksite personnel estimated the equivalent dose to the lungs as 290 mSv for the first year post-exposure. She died 31 years post-exposure at age 86. A total of 129 tissue samples from the right side of the body was radiochemically analyzed for ^{234}U, ^{235}U, and ^{238}U by alpha spectrometry. ^{236}U was measured in 20 tissue samples using thermal ionization mass spectrometry. Analysis of the lung tissues confirmed that the inhaled material was EU comprised of 67.2% of ^{235}U, 31.9% of ^{238}U, 0.7% of ^{234}U, and 0.2% of ^{236}U by weight. At the time of death, 27.1 ± 0.6 Bq of ^{234,235,238}U was retained in the respiratory tract, 0.29 ± 0.01 Bq in the kidneys, 0.056 ± 0.005 Bq in the liver, and 26.7 ± 0.1 Bq in the skeleton. Urine measurements, chest count results, and post-mortem activities in the lungs, liver, skeleton, and kidneys were simultaneously fitted using IMBA Professional Plus® to estimate the intake and the resulting radiation dose. A combination of chronic inhalation and two acute inhalation intakes appears to best describe the bioassay data. This individual was a heavy smoker that resulted in compromised particle clearance from the lungs to the thoracic lymph nodes. Data analysis results indicated that the models recommended by the International Commission on Radiological Protection (ICRP), with the adjustment for smoking status, adequately describe the biokinetics of inhaled EU except retention in the liver and kidneys. However, ICRP systemic models are mostly based on data from males and may not reflect female physiology. The best fit ($p = 0.739$) to all data including post-mortem tissue retention was achieved when the transfer rate from the liver to the blood was increased by a factor of 10 and that from the kidneys to the blood decreased by a factor of 2.1. The total intake was estimated to be 48.3 kBq, and the committed effective dose was 225 mSv with 97% contributed by ^{234}U. Of this dose, 96.8% was delivered to the respiratory tract tissues followed by red bone marrow (0.8%), bone surfaces (0.6%), liver (0.4%), and ovaries (0.4%).

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