

USTUR Case 0259 Whole Body Donation: A Comprehensive Test of the Current ICRP Models for the Behavior of Inhaled $^{238}\text{PuO}_2$ Ceramic Particles

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An analysis of ^{238}Pu in the whole body donation to the U.S. Transuranium and Uranium Registries (USTUR) is presented. This donor accidentally inhaled an unusual physical form of plutonium, predominantly the ^{238}Pu isotope in the form of a highly insoluble ceramic. Along with six other workers accidentally exposed at the same time, this donor excreted little or no ^{238}Pu in his urine for several months. Subsequently, however, and, with no further intakes, the urinary excretion of ^{238}Pu by all of these workers increased progressively. Such a pattern of increasing urinary excretion of plutonium resulting from a single acute inhalation was unknown at the time. The subject of this study provided a unique opportunity to analyze not only the pattern of urinary excretion for 17 y following this unusual intake but also the complete distribution of ^{238}Pu in his donated body tissues and skeleton at death. Radiochemical analyses of tissues from this whole body donation were used to perform critical tests of the applicability and accuracy of the respiratory tract model and the systemic biokinetic models for plutonium currently recommended by the International Commission on Radiological Protection. The respiratory tract model was applied to analyze the donor's long-term urinary excretion pattern. The facility provided by this model to the lungs into a more soluble form, applied in conjunction with the systemic biokinetic model, predicted the total amount of ^{238}Pu measured in the donor's body to within 17% accuracy. The measured division of ^{238}Pu between the donor's lungs and systemic organs was predicted to within 10%. Small adjustments to several rate constants in these models provided precise predictions of the absolute amounts of ^{238}Pu in the lungs, thoracic lymph nodes, liver, red bone marrow, skeleton (including the distribution of ^{238}Pu between trabecular and cortical bone matrices derived from the radiochemical analyses), kidneys, testes, and muscle. The resulting individual-specific parameters were applied to evaluate the equivalent dose rates and cumulative doses received by the donor's organs and the overall effective dose. Whereas these individual modifications to the ICRP models provided a more accurate representation of the distribution of dose between the donor's organs, it was determined that the ICRP models provided an adequate estimate of the overall effective dose.

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