Evaluating Plutonium Intake and Radiation Dose Following Extensive Chelation Treatment

Sara Dumit[1], Maia Avtandilashvili[1], Sergei, Y. Tolmachev[1]

[1]U.S. Transuranium and Uranium Registries, Washington State University, Richland, WA

A voluntary partial-body donor (U.S. Transuranium and Uranium Registries Case 0785) was accidentally exposed to ^{239}Pu via inhalation and wounds. This individual underwent medical treatment including wound excision and extensive chelation treatment with calcium ethylenediaminetetraacetic acid and calcium diethylenetriaminepentaacetic acid. Approximately 2.2 kBq of ^{239}Pu was measured in the wound site 44 y after the accident. Major soft tissues and selected bones were collected at autopsy and radiochemically analyzed for ^{238}Pu, ^{239}Pu, and ^{241}Am. Postmortem systemic retention of ^{238}Pu, ^{239}Pu, and ^{241}Am was estimated to be 32.0 ± 1.4 Bq, 2,172 ± 70 Bq, and 394 ± 15 Bq, respectively. Approximately 3% of ^{239}Pu whole-body activity was still retained in the lungs 51 y after the accident indicating exposure to insoluble plutonium material. To estimate the intake and calculate radiation dose, urine measurements not affected by chelation treatment, in vivo chest counts, and postmortem radiochemical analysis data were simultaneously fitted using Integrated Modules for Bioassay Analysis Professional Plus software. The currently recommended International Commission on Radiological Protection Publication 130 human respiratory tract model and National Council on Radiation Protection and Measurements Report 156 wound model were used with default parameters. The intake, adjusted for ^{239}Pu removed by chelation treatment, was estimated at approximately 79.5 kBq with 68% resulting from inhalation and 32% from the wound. Inhaled plutonium was predominantly insoluble type S material (74%) with insoluble plutonium fragments deposited in the wound. Only 1.3% reduction in radiation dose was achieved by chelation treatment. The committed effective dose was calculated to be 1.49 Sv. Using urine data available for this case, the effect of chelation therapy was evaluated. Urinary excretion enhancement factors were calculated as 83 ± 52 and 38 ± 17 for initial and delayed calcium ethylenediaminetetraacetic acid treatments, respectively, and as 18 ± 5 for delayed calcium diethylenetriaminepentaacetic acid. The enhancement factor decreases proportionally to an inverse cubic root of time after intake. For delayed calcium ethylenediaminetetraacetic acid treatment, with five consecutive daily administrations, the enhancement factor increased from day 1 to 4, followed by approximately a 50% drop on day 5. The half-time of plutonium ethylenediaminetetraacetic acid complex removal in urine was evaluated to be 1.4 d.

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