USTUR Whole Body Case 0262: 33-y Follow-up of PuO_2 in a Skin Wound and Associated Axillary Node

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ABSTRACT

This whole body donation case (USTUR Registrant) involved two suspected Pu inhalation intakes, each indicated by measurable Pu α-activity in a single urine sample, followed about 1½ y later by a puncture wound to the thumb while working on a Pu glovebox. This study is concerned with modelling simultaneously the biokinetics of deposition and retention in the respiratory tract and at the wound site; and the biokinetics of Pu subsequently transferred to other body organs, until the donor's death. Urine samples taken after the wound incident had readily measurable Pu α-activity over the next 14 y, before dropping below the minimum detectable excretion rate (< 0.4 mBq d^{-1}). The Registrant died about 33 y after the wound intake, at age 71 y, from hepatocellular carcinoma with extensive metastases to the right hemi-diaphragm, lungs and liver. At autopsy, all major soft tissue organs were harvested for radiochemical analyses of their ^{238}Pu, $^{239+240}Pu$ and ^{241}Am content. Also as per USTUR protocol, the skin of the hand bearing the thumb wound was harvested, together with the axillary (arm-pit) lymph node on that side of the body, and all bones (comprising about half the skeleton). Radiochemical analyses were performed on all sampled tissues, except for the hand skin (including the wound site). This was stored frozen in anticipation of future autoradiographic/histological study. So, for this biokinetic study, it was necessary to use a non-destructive assay of the plutonium remaining at the wound site. There was no visible scarring, so the wound site had first to be isolated within the larger skin sample. This was done by scanning the skin sample with an aperture-collimated low-energy planar Ge spectrometer (LEGe), detecting the 59 keV photons emitted by the ^{241}Am contaminant activity (incorporated in the Pu particles). The long-retained activity was found to be still highly localized within a region of less than 3 mm diameter, and at roughly central depth in the 5-mm-thick layer of skin. Thus, both the retained ^{241}Am and $^{239+240}Pu$ activities could be measured accurately using a point-source detector configuration, and correcting for the overlying tissue thickness. The amount of $^{239+240}Pu$ retained at the wound site was found to be 68 ± 7 Bq (1 S.D.). The $^{239+240}Pu$ activity retained in the axillary lymph node was 56.0 ± 1.2 Bq (from radiochemical analysis). The total $^{239+240}Pu$ activity retained at the wound site and its associated lymph node (124 Bq) represented 67% of total body burden at the time of death. The urinary excretion data was simulated by coupling the ICRP Publication 66 respiratory tract model with a simple (first order) multi-compartment model to represent particle retention at the wound site and the fractional transfer to the axillary lymph node, and with the ICRP Publication 67 biokinetic model for systemic Pu. The maximum likelihood method was then used to estimate the amounts of intake. The resulting most likely intakes were 757 and 1,504 Bq, respectively, for the inhalations, and a total wound intake of 204 Bq. The inhaled material was highly insoluble (long-term dissolution rate 2×10^{-5} d^{-1}). The material deposited at the wound site was mixed; about 14% was rapidly absorbed, about 49% was absorbed at the rate of about 6×10^{-5} d^{-1}, and the remainder (about 37%) was absorbed extremely slowly (at the rate of about 5×10^{-5} d^{-1}). Thus, it was estimated that only about 40% of the Pu initially deposited in the wound had been absorbed systemically over the 33-y period until the donor's death. This presentation will outline the methods used to analyze the excretion and tissue content data, and also the individual-specific values of transfer rate constants required to be substituted in the ICRP models to match the measured systemic tissue distribution of Pu. The complete dataset for this case will be published on the USTUR's web site (http://www.ustur.wsu.edu/WB_Studies/Case_0262).

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