

Modelling of Long-Term Retention of High-Fired Plutonium Oxide in the Human Respiratory Tract: Importance of Scar-Tissue Compartments

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The U.S. Transuranium and Uranium Registries whole-body tissue donor Case 0407 had an acute intake of 'high-fired' plutonium oxide resulting from a glove-box fire in a fabrication plant at a nuclear defense facility. The respiratory tract of this individual was dissected into five regions (larynx, bronchi, bronchioles, alveolar-interstitial, and thoracic lymph nodes) and analyzed for plutonium content. The activities in certain compartments of the respiratory tract were found to be higher than expected from the default models described in publications of the International Commission on Radiological Protection. Because of the extremely slow rate of dissolution of the material inhaled, the presence of bound fraction is incapable of explaining the higher-than-expected retention. A plausible hypothesis - encapsulation of plutonium in scar tissues - is supported by the review of literature. Therefore, scar-tissue compartments corresponding to the larynx, bronchi, bronchioles and alveolar-interstitial regions were added to the existing Human Respiratory Tract Model structure. The transfer rates between these compartments were determined using Markov Chain Monte Carlo analysis of data on urinary excretion, lung counts and post-mortem measurements of the liver, skeleton and regional retention in the respiratory tract. Modelling of the data showed that approximately 30% of plutonium activity in the lung was sequestered in scar tissues. The dose consequence of such sequestration is qualitatively compared against that of chemical binding.

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