Plutonium in human brain: Is more biokinetic detail needed for dosimetry?

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Introduction
Biokinetic model for systemic plutonium is used to estimate internal radiation doses to organs and tissues. The brain is not included explicitly in the model but is aggregated into a pool called Other tissue in which activity is assumed to be uniformly distributed. Explicitly identified tissues are liver, bone, bone marrow, kidneys, and gonads. Due to increasing interest in potential adverse effects of radiation on the brain, efforts are underway within the Million Person Study to improve brain dosimetry for both internal and external radiation sources.

The purpose of this study was to assess potential improvements in brain dosimetry for incorporated plutonium from explicit modelling of brain kinetics.

Methods
The most relevant data available for modelling brain kinetics of plutonium are autopsy data for individuals occupationally exposed to this element. The U.S. Transuranium and Uranium Registries (USTUR) has studied the biokinetics and tissue dosimetry of actinides in nuclear workers. Plutonium (²³⁹Pu) activities in brains were measured for 70 individuals. In 31 cases, Brain / (Liver + Skeleton) activity ratios were estimated to modify plutonium systemic model by explicitly adding brain compartment. Plutonium brain dosimetry was evaluated for two alternate versions of the systemic biokinetic model: (a) with the brain as an implicit mass fraction of Other tissue and (b) with explicit modelling of brain kinetics. Dose coefficients for ²³⁹Pu based on both versions of the biokinetic model were calculated and compared.

Results
²³⁹Pu activity concentrations in brain tissue of occupationally exposed individual ranged from 0.0003 to 4.4 Bq kg⁻¹ with a median of 0.027 Bq kg⁻¹. A median value for these individuals, the brain contains ~0.2% as much ²³⁹Pu as liver and skeleton combined. A single compartment representing brain was added to the plutonium biokinetic model, and parameter values were set to yield a long-term total activity ratio Brain/(Liver + Skeleton) of 0.002.

Dose coefficient for brain for acute ²³⁹Pu input to blood was 0.022 mSv Bq⁻¹ based on biokinetic model with brain included in Other tissue and 0.026 mSv Bq⁻¹ based on modified version with an explicit brain compartment. The dose coefficient based on the modified model with an explicit brain compartment is 0.96 times the value based on the model with implicit brain.

Conclusions
The results of the study to this point suggest that explicit biokinetic modelling of a brain pool for plutonium is not likely to result in significant difference in estimated dose to the brain.

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