Validation of Proposed Revisions to ICRP Human Respiratory Tract Model Using Human Data Associated with an Acute Inhalation of Refractory PuO₂

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Introduction

The International Commission on Radiological Protection is currently reviewing and updating its biokinetic and dosimetric models, including the Human Respiratory Tract Model (ICRP 66).

Objectives

- Examine the applicability of the ICRP HRTM and Gregoratto et al. (GPT) model.
- Optimize the parameter values of GPT model to represent USTUR case 0202 and 0407 data.
- Calculate the probability distributions on intake, biokinetic model parameters and doses.
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Pu fire at the Rocky Flats Plant, October 15, 1965

- Air contamination over ~7000 work area due to plutonium fire outside the glove box.
- Highly refractory "high fired" PuO₂ aerosol particles: 0.32 μm HMD (1.0 μm AMAD).
- About 400 workers monitored: 25 received intakes greater than HPLB.
- Ca-ETRA administration: 8 workers for 4-5 days each.
- 18 US Transuranium and Uranium Registry tissue donors.

Methods

- Maximum Likelihood Method
- Bayesian Statistical Analysis

1PP Maximum Likelihood Assessment

- Implementation of ICRP particle transport and Type S absorption models along with the ICRP Publication 67 model for Pu systemic behavior (ICRP 1990) resulted in a non-credible fit to the bioassay data for both cases.

WelMoS Bayesian Analysis

- Gregoratto et al. particle transport model (GPT) coupled with customized absorption model parameter resulted in a credible fit to urinary excretion data for both cases and predicted the case 0202 liver and skeletal activities as measured post-mortem.
- Since the lung retention data was acceptable for case 0407, however, the model did not predict the lung data for case 0202.

Conclusions

- With appropriate adjustments, Gregoratto et al. model yielded an acceptable fit to the bioassay data for both cases and predicted the Case 0202 liver and skeletal activities measured post-mortem.
- More significant adjustments to GPT model structure and rate constants are required to represent case 0202 data than it is necessary for case 0407.
- However, the optimized GPT model parameters are consistent for both cases within the 68% probability range for the intersubject variability.

References

- Birchall A et al. ICRP. 2007. Post-Mortem Tissue Activity Data: USTUR Donor 0202's lung disease and prior exposure to coal dust are likely to have impaired lung clearance.

“Optimization” of Gregoratto et al. Particle Transport Model

- Calculations performed for Case 0202 and Case 0407 data fits given by GPT.
- Posterior probability distributions of intake, effective dose and model parameters: a) Case 0202; b) Case 0407.