Evaluation of the NCRP wound model using USTUR plutonium-contaminated wound cases

Liesl Germann

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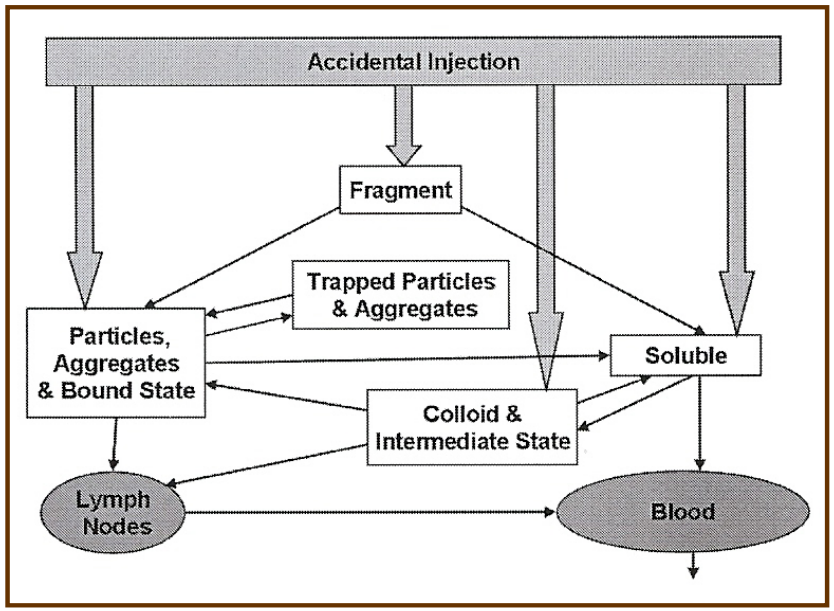
IDAHO STATE UNIVERSITY

NCRP Report No. 156 – Wound Model

"Development of a Biokinetic Model for Radionuclide-Contaminated Wounds for Their Assessment, Dosimetry and Treatment" (2007)

- First formal attempt to develop a conceptual model of the pathways involved in radionuclide retention in a wound and the associated lymph nodes
- Overall wound retention predicted by equivalent sums of exponential retention functions
- Recommended default parameter values characterize retention and systemic uptake – derived from experimental animal data
- Emphasis on solution chemistry
  - 4 solution categories - weak, moderate, strong, avid
  - colloid category
  - 2 solid categories - particle, fragment



The NCRP biokinetic model of radionuclide translocation from a wound site as published in NCRP Report No. 156 (2007).

USTUR Case Applications

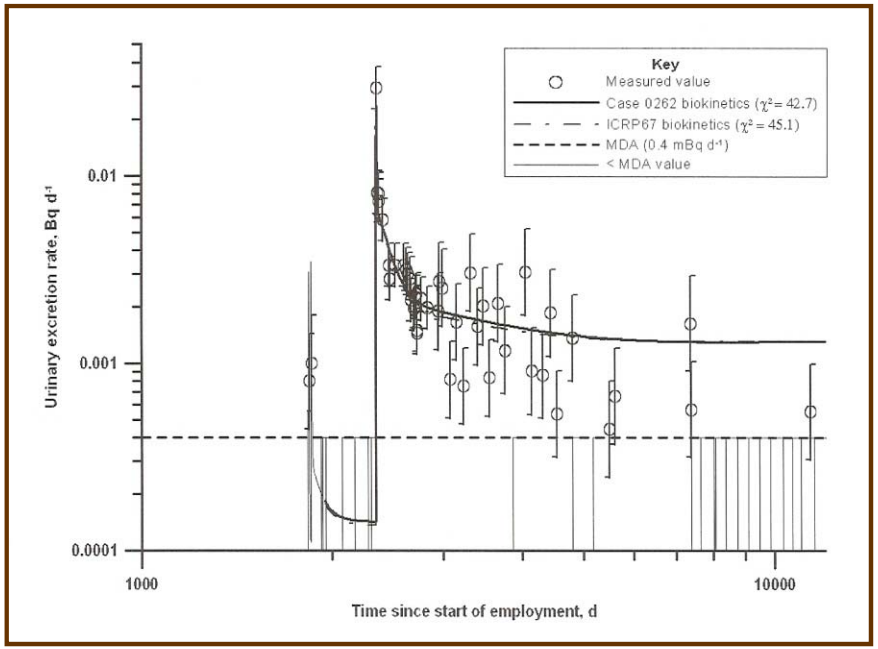
- Much of the data that contributed to the formulation of the NCRP wound model's retention coefficients originated from animal experiments and has been extrapolated to humans
- Specific tests of its applicability to the human metabolic system are needed
- USTUR wound cases allow testing of default retention parameters using real-life worker wound incidents

Especially plutonium cases:

- many plutonium-contaminated wound cases
- variety of wound types
- variety of plutonium mixtures

USTUR Case 0262 – James et al. (2008)

- Pu puncture wound to the skin of the thumb obtained while working with Pu materials in a glovebox
- Absorption rate constants were determined iteratively - optimum fit obtained ($\sum\chi 2 = 42.7$)
- 40% of the Pu initially deposited in the skin wound was absorbed slowly over the 33 years following the accident - other 14% was absorbed quite rapidly
- Mixture of insoluble $^{239}PuO_2$, and a more soluble Pu form



Optimum fit to the urinary excretion data for USTUR Case 0262 obtained by James et al. (2008).

USTUR Case 0262 – Poster Study

IR1 = weak

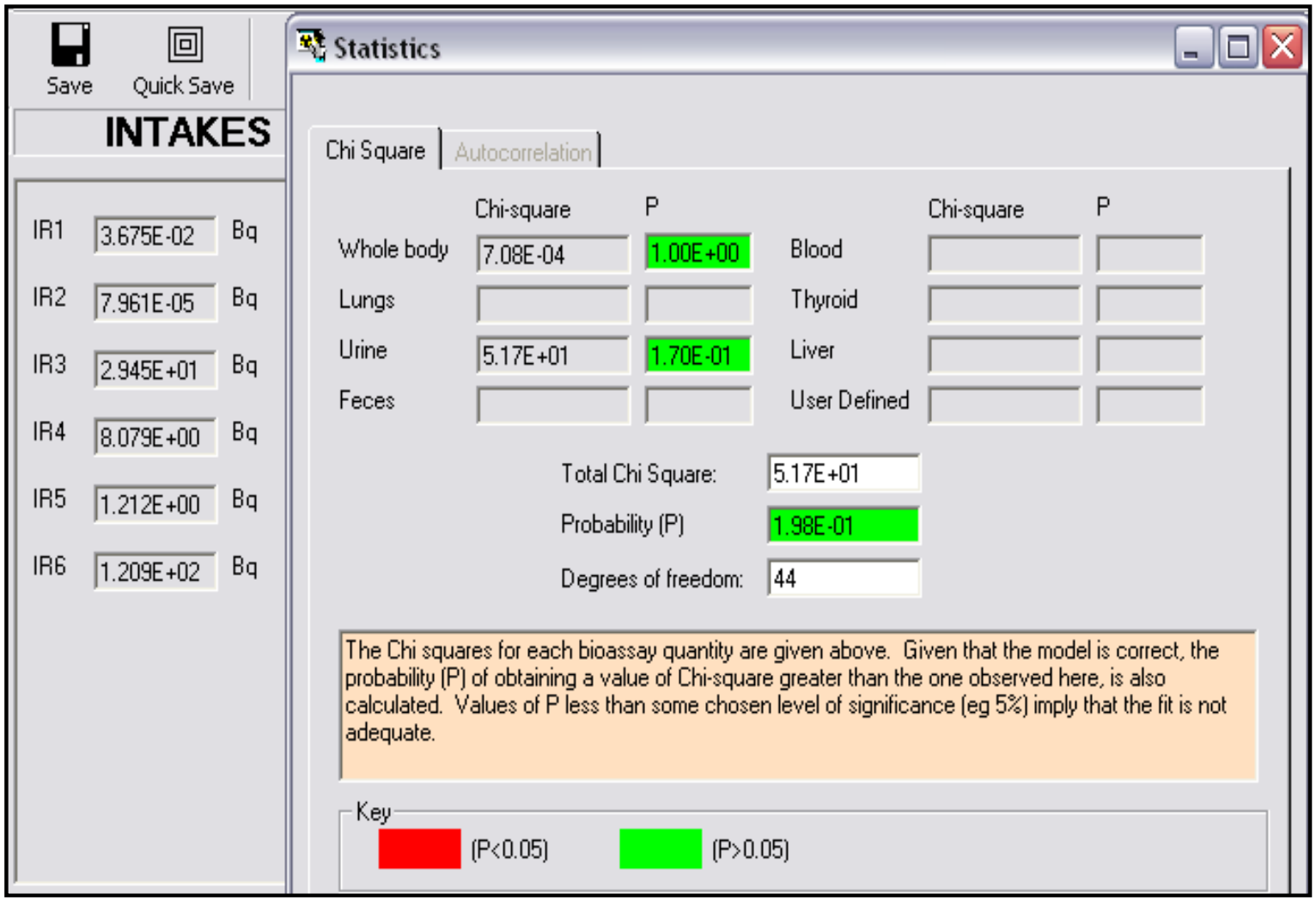
IR2 = moderate

IR3 = strong

IR4 = avid

IR5 = particle

IR6 = fragment



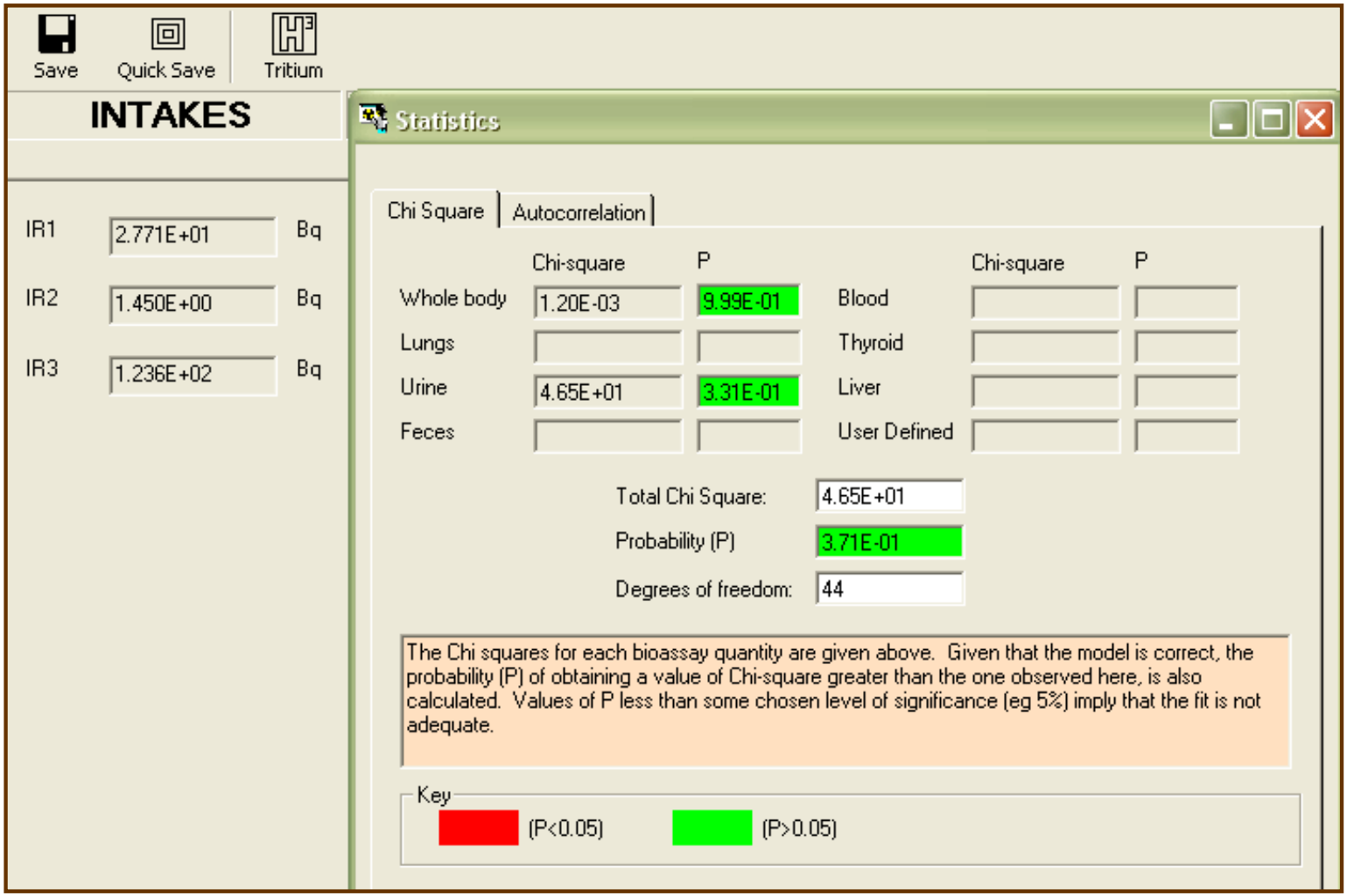
Fitted apportionment of NCRP wound absorption categories from Case 0262 data, and the resulting statistical parameters.

USTUR Case 0262 – NCRP Study

IR1 = strong

IR2 = avid

IR3 = fragment

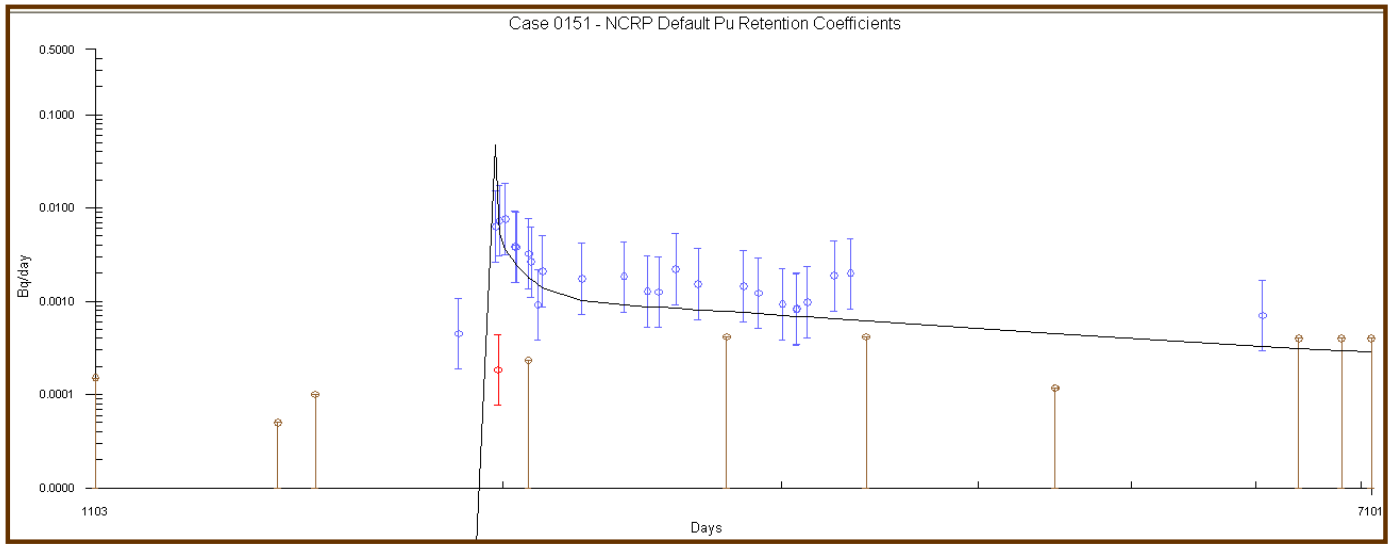


Fitted apportionment of NCRP plutonium wound absorption categories for the optimized fit from Case 0262 data, and the resulting statistical parameters.

USTUR Case 0262 – Comparisons

- Very similar chi-squares obtained in best fit solutions
  - Iteration $X^2 = 46.5$
  - NCRP $X^2 = 42.7$
- Autocorrelation statistically significant in both analyses
- Small soluble component indicated in both analyses
  - James et al. – 14% soluble
  - NCRP study – strong and avid categories represented
- Not all plutonium mixtures are represented by the NCRP default retention coefficients:
  - the Pu compound involved in the Hanford incident was likely NOT fragment
  - the fragment category received the greatest apportionment
  - the particle category received insignificant apportionment
  - indicates that a slower particle retention coefficient is needed

USTUR Case 0151



- Plutonium intake in 1950s from puncture wound on left ring finger acquired while working in a process hood at Hanford
- Statistically significant fit ($\sum\chi 2 = 16.$) – all 4 categories required to obtain minimum chi-square
- Autocorrelation coefficient not significant
- Apportionment of NCRP wound absorption categories indicate that the Pu material was more soluble than the Case 0262 mixture

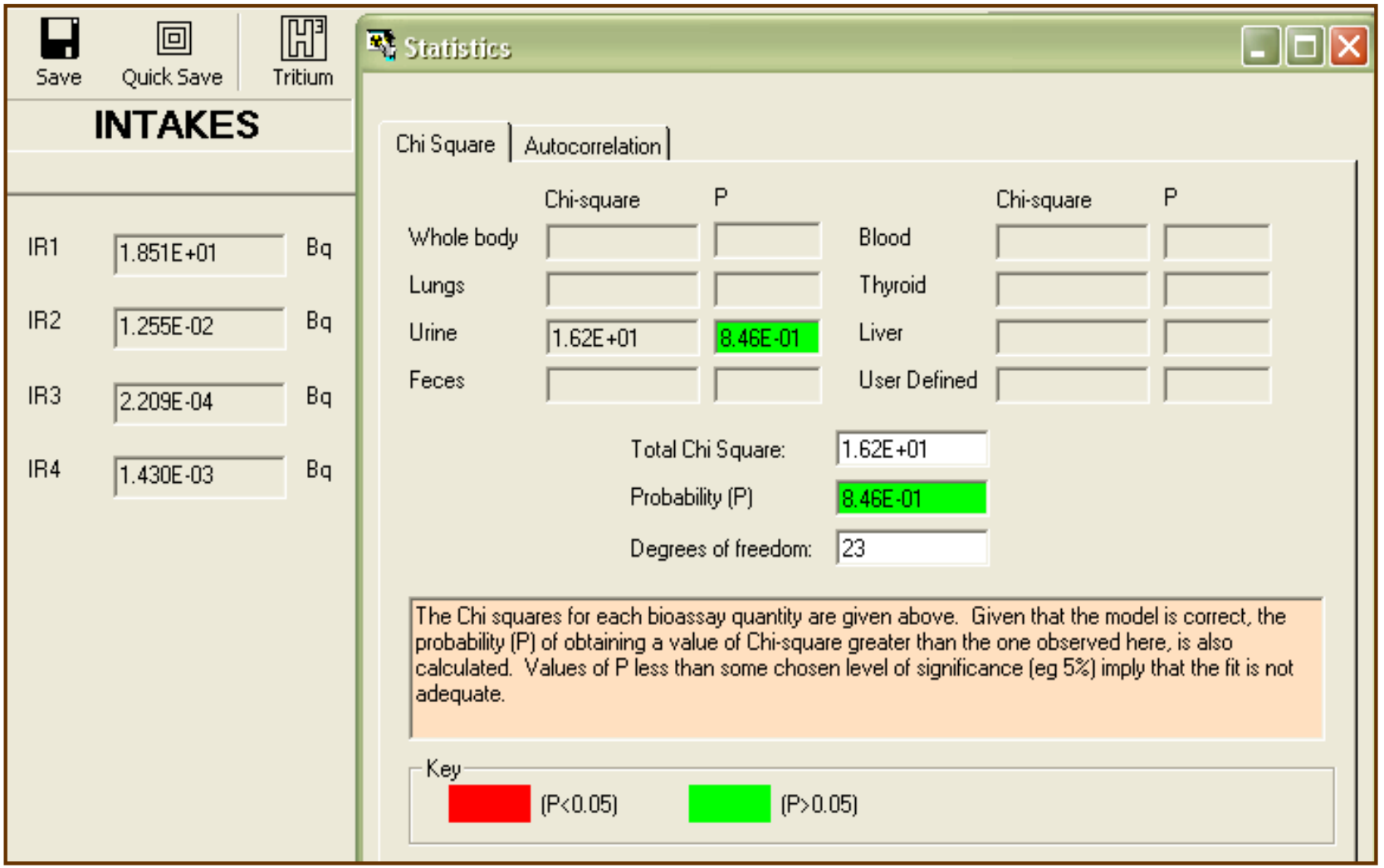
USTUR Case 0151

IR1 = strong

IR2 = avid

IR3 = particle

IR4 = fragment



Fitted apportionment of NCRP plutonium wound absorption categories from Case 0151 data, and the resulting statistical parameters.

Summary

The U.S. Transuranium & Uranium Registries provide real cases of plutonium-contaminated wounds with which to test the ability of the new NCRP Report No. 156 wound model's default retention parameters to predict systemic plutonium uptake in the human metabolic system.

Continuing Work:

- Search for additional Pu intake cases free from confounding factors:
  - Inhalations
  - Chelations
  - Additional wounds
- Application of various combinations of the NCRP recommended default retention coefficients for Pu chemistry
- Optimum fit to the bioassay data that minimizes chi-square and autocorrelation coefficient

References

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