



# Four Decade Follow Up of Plutonium Contaminated Puncture Wound Treated with Ca-DTPA

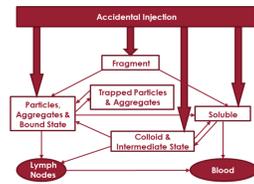
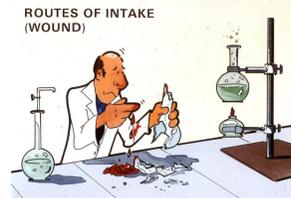
Maia Avtandilashvili and Sergei Y. Tolmachev

United States Transuranium and Uranium Registries, College of Pharmacy and Pharmaceutical Sciences, Washington State University  
1845 Terminal Drive, Richland, WA 99354, USA



## Motivation

- Contaminated wound is a common route of internal deposition of radionuclides for nuclear and radiation workers
  - >2,000 accidents reported (NCRP 2007)
- May result in significant doses to the radiosensitive organs and tissues
  - Typically treated by tissue excision and chelation
- NCRP 156 Wound Model (2007) based exclusively on animal data



### Default Material Types

- Soluble: Weak, Moderate, Strong, Avid
- Colloid
- Particle
- Fragment

## U.S. Transuranium and Uranium Registries (USTUR)

- Established by U.S. Atomic Energy Commission in 1968
- Since 1992, operated by College of Pharmacy at Washington State University as a research grant funded by U.S. Department of Energy
- Follows up occupationally exposed workers, from exposure through full lifespan, by studying the biokinetics (uptake, translocation and retention), and tissue dosimetry of the actinides (Pu, Am, and U).
- Retains data from 34 living and 355 deceased Registrants.
- 19 USTUR registrants had recorded <sup>239</sup>Pu wound(s) as major intake route: 8 whole-body, 11 partial-body
  - Chelation treatment administered to 5 of 19
  - Follow-up bioassay available: urine, wound counts
  - Post-mortem tissue analyses: liver, skeleton, wound



## Pu contaminated wound

- The USTUR whole-body donor accidentally punctured his finger while working in the hood gloves.
- The wound was contaminated with plutonium nitrate.
- Initial survey meter reading: 20,000 dpm
  - Decontaminated to ~5,000 dpm
- Worksite personnel estimated initial wound activity as ~4.1 kBq of <sup>239</sup>Pu



## Treatment

- Contaminated tissue was excised twice: ~2.3 kBq was removed
  - 59 Bq was measured in wound a month later
- Chelation treatment was administered
  - 16 g Ca-DTPA in 18 i.v. injections
  - Over two months post-intake



## Bioassay

83 valid urine measurements

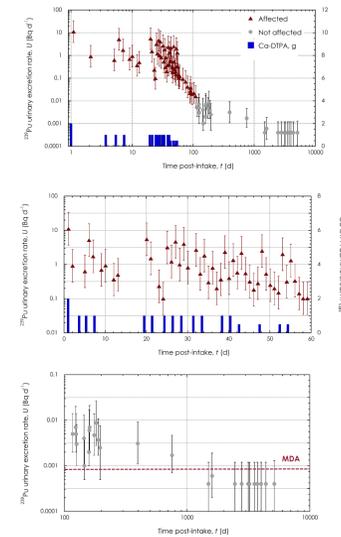
- Autoradiography
- MDA: ~0.8 mBq

57 measurements affected by DTPA

- Max rate: 11.2 Bq d<sup>-1</sup> on day 1
- Total Pu excreted: 77.8 Bq

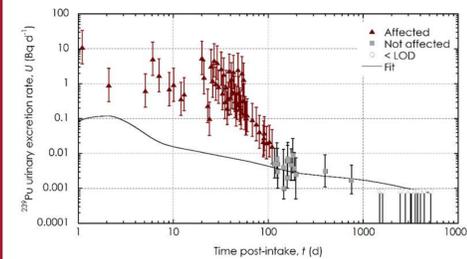
26 'post-treatment' measurements

- Average rate: 3.0 ± 2.5 mBq d<sup>-1</sup>
- < MDA after 1,000 d post-intake



## Results

Max likelihood fit:  $\chi^2$  alpha > 0.05



Pu retention at time of death, Bq

Organ	Predicted	Measured
Liver	10.9	12.2
Skeleton	15.4	17.5
Wound	0	1.4

Bound Pu in wound ??

### Intake

- IMBA estimate: 47.6 Bq
- Pu excreted with DTPA: 77.8 Bq
- Total: 125.2 Bq

### Committed Effective Dose

- Residual: 24 mSv
- vs
- Projected: 63 mSv

## Tissue Radiochemical Analysis

Tissue	Concentration, Bq kg <sup>-1</sup>	Activity, Bq
Wound		
Right 2 <sup>nd</sup> finger	n/a	1.35 ± 0.03
Right axillary LN	0.39 ± 0.14	0.0018 ± 0.0006
Skeleton (7 samples)	1.58 ± 0.06	17.5 ± 0.7
Liver	8.5 ± 0.2	12.2 ± 0.3
Lungs	0.088 ± 0.004	0.136 ± 0.007
Thoracic LN	0.18 ± 0.07	0.006 ± 0.002
Kidneys	0.15 ± 0.01	0.041 ± 0.003
Heart	0.20 ± 0.01	0.23 ± 0.01
Brain	0.094 ± 0.005	0.112 ± 0.007

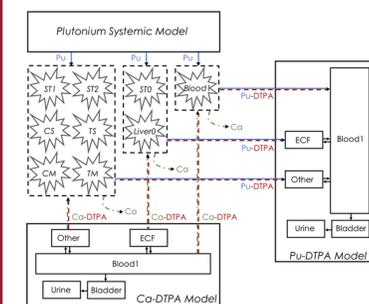
### Concentration

- Axillary LN ~ other soft tissues
- Wound intake of soluble Pu

### Activity

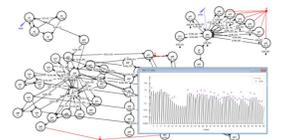
- Lungs : Liver << 1
- No significant inhalation

## Future Work



Apply the system of models for Pu decorporation (Dumit et al. 2018) to:

- simultaneously fit DTPA-affected and not-affected urine data
- Improve, validate and optimize the proposed system of models



## Acknowledgement

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## References

- NCRP. Report 156. 2007
- Birchall et al. *Radiation Protection Dosimetry* 125: 194-197; 2007
- Leggett et al. *Radiation Research* 164: 111-122; 2005
- Dumit et al. *Radiation Research* 2018 (submitted).

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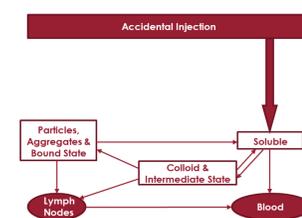
## Data Analysis Method

- IMBA Professional Plus® (Birchall et al. 2007)
  - Special academic edition
  - Allows to build and solve systemic models



## Models

NCRP 156 Wound Model (2007)  
Soluble strong material



Pu systemic model (Leggett et al. 2005)

