

# Modeling Pu Decorporation Therapy Following Occupational Exposure

Sara Dumit, Maia Avtandilashvili, and Sergei Y. Tolmachev

United States Transuranium and Uranium Registries, College of Pharmacy, Washington State University

1845 Terminal Drive, Richland, WA 99354, USA



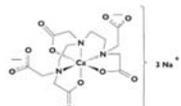
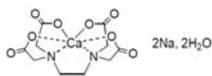
## United States Transuranium and Uranium Registries (USTUR)

- Federally-funded human tissue research program, founded in 1968
- Follow up occupationally exposed workers, from exposure through full lifespan, by studying the biokinetics (uptake, translocation and retention), and tissue dosimetry of actinides (Pu, Am, U)
- Unique resource of data from former nuclear workers and significant impact on national and international advisory bodies
- Performs autopsies and radiochemically analyzes collected tissue samples and applies obtained data to refine internal radiation dose assessment methods

## Introduction

- High levels of exposure to actinides can cause severe health effects. Individuals with significant internal contamination typically undergo treatment with decorporation agents to accelerate urinary excretion and thus reduce radiation dose to sensitive tissues
- Plutonium is an alpha emitter, used in nuclear weapons and nuclear power generation, with global inventory of 505 tons
- Plutonium in humans:
  - General public - global fallout
  - Occupational - nuclear operation, decommission

- Agents for plutonium decorporation:



Ca-EDTA (Ethylenediamine Tetra Acetic Acid)

Ca/Zn-DTPA (Diethylene Triamine Penta Acid)

- Why do we care?

Nuclear accidents still happen, 'Dirty' bomb threat, compensation claims (\$12.3 billion)

## Motivation, Objectives, and Significance

- Motivation
  - No accepted model for decorporation
- Objectives
  - Develop, parameterize and validate a generic biokinetic model for plutonium decorporation therapy
- Significance
  - Interpretation of bioassay measurements under treatment conditions
  - Optimization of actinides decorporation treatment

## Case Study

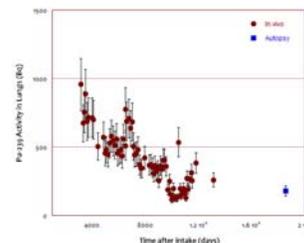
- USTUR Case 0785 was selected for this study. This individual was exposed to plutonium nitrate via inhalation and wounds due to an explosion at the defense nuclear facility
- Plutonium systemic burden 7,400 Bq (five times greater than permissible amount)
- Decorporation therapy was initiated on the day of the accident
  - Immediately: 1-2 g Ca-EDTA, 2 i.v. per day, 4 weeks
  - 9 months post-accident: 2 g Ca-EDTA, 2 i.v. per day, 2 weeks
  - 7 years post-accident: 1 g Zn-DTPA, 1 i.v. per week, 10 weeks
- Wound excision
  - 3 weeks post-accident: 7,344 Bq of plutonium was removed



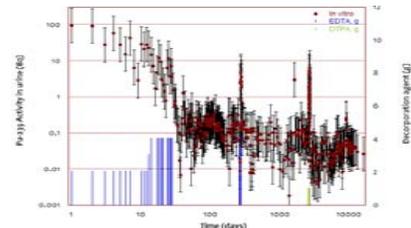
## Materials and Methods

- Human Data

In-vivo: lung counts (74 measurements)



In-vitro: urinalysis (478 measurements of plutonium in urine)



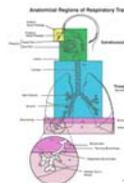
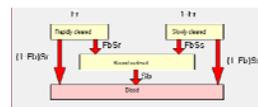
Autopsy: tissue radiochemical analyses

Tissue/Organ	Pu Concentration, Bq kg <sup>-1</sup>	Pu Activity, Bq
Lungs	18.2 ± 0.3	24.6
Thoracic Lymph Nodes (LNTH)	8,199 ± 15.6	151.1
Liver	548 ± 36	602.0
Skeleton	209 ± 8	1,936
Total Systemic	-----	7,800

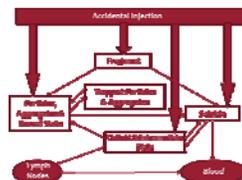
LNTH:Lung ratio = 455 (!!!) – exposure to very insoluble material

- Models

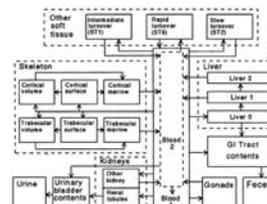
Human Respiratory Tract Model: International Commission on Radiological Protection (ICRP 130)



Wound Model: National Council on Radiation Protection and Measurements (NCRP 156)



Systemic Model: Leggett et al, 2005



- Software

Integrated Modules for Bioassay Analysis (IMBA) Professional Plus®



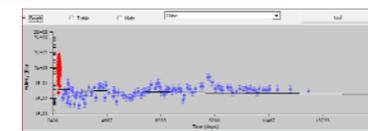
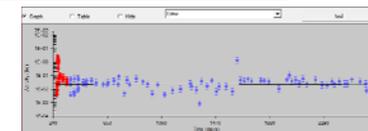
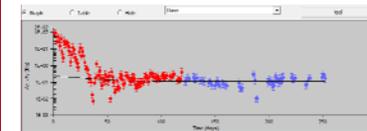
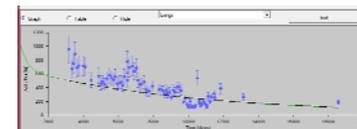
## Preliminary Results

- Plutonium decorporation: 683 Bq

- Estimating Intake

Inhalation: 33,050 Bq

Wound: 1,084 Bq



## Conclusions

- Exposure to highly insoluble Pu material
- Estimated intake was 34,817 Bq
- Major internal contamination from inhalation (97%)
- Systemic deposition 51 y post-intake was 2,800 Bq with skeleton-to-liver activity ratio of 3:1

## Future Directions

- Modify the default ICRP model parameters to find the best estimate of the intake
- Develop and parameterize plutonium decorporation model
- Validate model using USTUR data (6 cases)

## Acknowledgments

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