Chelation Treatment after Occupational Exposure to Plutonium

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

Objectives

- Plutonium biokinetic modeling under chelation treatment
- Estimating plutonium intake and radiation dose
- Evaluating effectiveness of chelation treatment

USTUR Case 0785

- Primary exposure: Plutonium (Pu)
- Exposure scenario: Acute inhalation and wound
- Material type: M (assumed)
- Smoking status: 38 y (0.5 pack per day)
- Cause of death: Lung cancer
- Post-intake: 51 y
- Age: 79 y

Source: scandinavianlense.wordpress.com

Accident

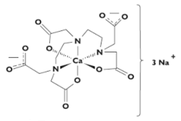
- Glove-box explosion; Working with plutonium nitrate solution
- Face, hair, neck, hands, and forearms contamination
- Facial wound deposition 8,032 Bq
- Plutonium systemic burden 7,400 Bq (worksite)

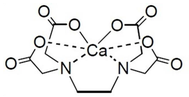
Five times higher than permissible amount

Treatment

Chelation Therapy

- 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





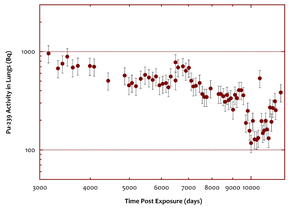
2Na, $2H_2O$

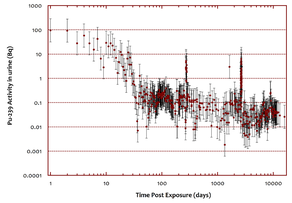
Wound Excision

- 3 weeks post-accident: 7,344 Bq of plutonium was removed

Bioassay Measurements

- *In-vivo*: 74 lung counts
- *In-vitro*: 478 urinalyses





^{239}Pu activity in lungs (left) and urine (right)

Autopsy Tissue Analysis

- Total of 32 tissue samples
- $^{238,239+240}$Pu concentration measured
- Total tissue/organ activity estimated

Tissue/Organ	$^{239+240}$Pu Concentration, Bq kg^{-1}	$^{239+240}$Pu Activity, Bq
Lungs	18.2 ± 0.3	24.6 ± 0.4
LNTH	5,884 ± 98	108.7 ± 1.8
Liver	548 ± 36	602.0 ± 40
Skeleton	209 ± 8	1,936 ± 74
Total Systemic	-------	2,728 ± 84

LNTH:Lung concentration ratio = 323

Exposure to very insoluble material ('Super' S)

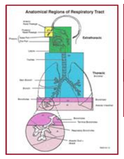
IMBA Professional Plus®

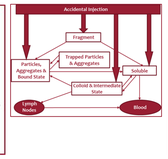
- A suite of software modules for internal dosimetry
- Implements all current biokinetic and dosimetric models
- Enables the user to:
  - ✓ Estimate an intake from bioassay measurement data
  - ✓ Predict bioassay quantities from a specific intake
  - ✓ Calculate resulting doses

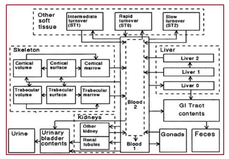
Data Analysis

Biokinetic Models

- International Commission on Radiological Protection Human Respiratory Tract Model (ICRP 130)
- National Council on Radiation Protection and Measurements Wound Model (NCRP 156)
- Leggett Plutonium Systemic Model (Leggett *et al*, 2005)



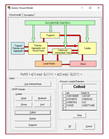


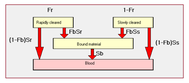


Source: courtesy of WJ Blair

Assumptions

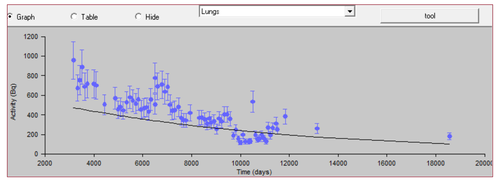
- Particle size: 1 µm AMAD
- Lung absorption type: Slow (S)
- Wound retention category: Insoluble colloid

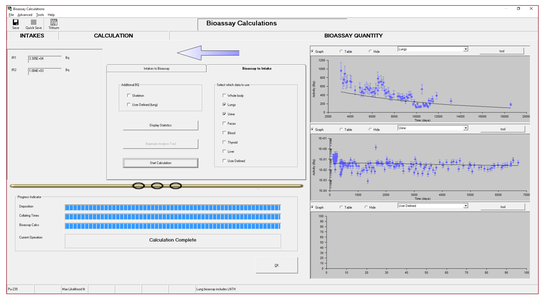




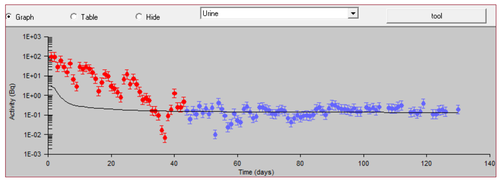
Estimating Residual Intake: Activity not Removed by Chelation Therapy

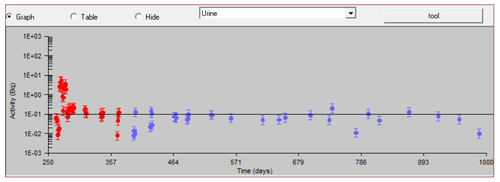
- Lungs

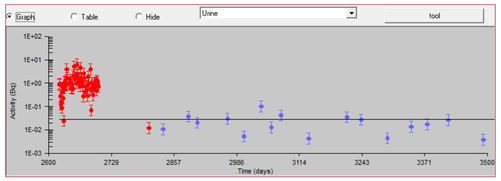




- Urine





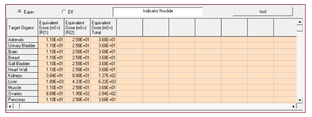


- Inhalation: 33,050 Bq (97%)
- Wound: 1,084 Bq (3%)

Total Intake and Dose Estimation

- Intake
  - ✓ Residual intake: 34,134 Bq
  - ✓ Pu removed by chelation: 683 Bq

  + } 34,817 Bq
- Committed Effective Dose
  - ✓ Residual CED: 1.09 Sv
  - ✓ Projected CED: 1.11 Sv



Conclusions

- Exposure to highly insoluble plutonium
- Systemic deposition 51 years post-intake was 2,728 Bq
- Major internal contamination from inhalation (97%)
- Estimated intake was 34,817 Bq
- Estimated committed effective dose was 1.09 Sv
- Only 2% dose was saved by chelation treatment

Podium Presentation

The results were also presented at the 61st Annual Meeting of the Health Physics Society: July 17 - 21, 2016 Spokane, WA as a part of *USTUR: Five Decade Follow-up of Plutonium and Uranium Workers* special session

Funding

- The United States Transuranium and Uranium Registries (USTUR) is funded by U.S. Department of Energy, Office of Domestic and International Health Studies (AU-13), under Grant Award No.: DE-HS0000073
- This work was supported by CAPES, Coordenação de Aperfeiçoamento de Pessoal de Nível Superior, Brazil, under Grant Award No.: 13355-13-9

References

- Birchall A *et al*. The IMBA suite: integrated modules for bioassay analysis. Radiat Prot Dosim 79: 107-110 (1998)
- Dumit, S., Avtandilashvili, M., Breustedt, B. and Tolmachev, S. Y. USTUR Case 0785: Modeling pu decorporation following complex exposure. Health Physics. 111(Suppl 1), 41 (2016)
- ICRP. Occupational Intakes of Radionuclides: Part 1. ICRP Publication 130 (2015)
- Leggett *et al*. Mayak Worker Study: An Improved Biokinetic Model for Reconstructing Doses from Internally Deposited Plutonium Rad Res 164; 111 – 122 (2005)
- NCRP. Development of a Biokinetic Model for Radionuclide contaminated Wounds and Procedures for their Assessment, Dosimetry and Treatment. Report No 156 (2006)