USTUR Case 0846:
Modeling Americium Biokinetics after Intensive Decorporation Therapy

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“Learning from Plutonium and Uranium Workers”
Why using USTUR data for chelation therapy modeling?

- DTPA chelation therapy removes “accessible” $^{241}$Am in extracellular fluids
  - How are extracellular fluids in ICRP models represented?

- Example
  - (USTUR Case 0269)
  - ST0 compartment
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- Example
  - (USTUR Case 0269)
  - ST0 compartment
  - ST0 + liver (x %)
- Fit to urine data possible for several assumptions
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- Example
  (USTUR Case 0269)
  - ST0 compartment
  - ST0 + liver ($x\%$)
- Fit to urine data possible for several assumptions
- Different predictions of effect of therapy
Why using USTUR data for chelation therapy modeling?

- USTUR has a large collection of data of chelated cases
  - Health Physics Database
    - Urinary and Fecal excretion
    - In-vivo counting (mainly for $^{241}$Am)
  - Autopsy data
    - Provides insight at distribution after therapy
Case 0846 – Scenario

• Manufacturing sources containing $^{241}$AmO$_2$
  ✓ 50 compacts manufactured over 3 years

• Compacting/pressing of pellet in pressing hood
  ✓ Half-mask respirator worn for transfer and compacting
  ✓ A “small” amount of visible dust was sometimes released during the pressing operation in the hood

• Alpha activity was detected in urine samples
  ✓ Worker was sent to WBC
  ✓ Estimated body burden = 1.8 mCi = 66.7 kBq (36 times the Maximum Permissible Body Burden)
Case 0846 – Therapy and Bioassay

• Removed from work and chelation therapy started

• 380 week therapy
  ✓ total administration of 313.5g Ca-DTPA
    • 330 i.v. of 1g Ca-DTPA: once a week
    • 57 i.v. of 0.5g Ca-DTPA: twice per week
    • 43 weeks without treatment

• Extensive Bioassay Measurements under Treatment
  ✓ Weekly body counts until week 60 of therapy
  ✓ Fecal collection until week 80
  ✓ Virtually all urine has been collected under therapy
    ▪ Daily collection in the first two years of therapy
    ▪ Weekly collection in the following 5 years
    ▪ One week per month in the last year
Case 0846 – Materials

• The case has been studied intensively (in 1960s - 1970s)
  ✓ Several reports and papers in Health Physics Journal
  ✓ Chapter in book for HPS Summer School 2004

• Bioassay data, exposure and medical records are available at USTUR
Case 0846 – The Dataset

- Data were collected and standardized in MS Excel file
Case 0846 – Original Analysis

• Pre ICRP Publication 30 era
  ✓ Empirical equations, no compartmental models

• Assumptions
  ✓ average intake 2 years before therapy
  ✓ “DTPA complexes americium and plutonium as soon as it leaves bone surfaces and transports the complex to urine for excretion”

• Conclusions
  ✓ Half of the body burden removed is by action of DTPA
  ✓ 7 years post therapy “the body burden was 0.72mCi with most of remaining burden in bones”

Quotes taken from: Allen Brodsky and Niel Wald @ HPS SummerSchool 2004
ICRP compartmental models and reference values

- Lung (ICRP 66, Class M)
- Americium systemic (ICRP 67)
- GIT (ICRP 30, $f_1=0.005$)

Definition of initial scenario using pre-therapeutic data and information

- Urine: 8.14 Bq/d
- Whole body 66.7 kBq

Acute intake

- 1.2 MBq $^{241}$Am
- 380 days before therapy
Case 0846 – New Analysis

- CONRAD Model of DTPA therapy
  - 3 compartmental systems
    - $^{241}$Am
    - DTPA (injected)
    - $^{241}$Am-DTPA (chelates)
  - Coupling (2nd order kinetics)
    - Parameter $K_c$

- Original CONRAD Model
  - Chelation only in ST0 compartment

- Modified EURADOS Model
  - Chelation also in other compartments
Case 0846 – New Analysis (Cont’d)

- Daily urinary excretion data
  - Effect of DTPA at day after injection
  - Elevated and steeper Baseline in between
  - Enhancement factor: ~5

![Graph showing urinary excretion data with DTPA injections at 1g and 2x0.5g per week](image-url)
Case 0846 – New Analysis (Cont’d)

• Fitting daily urinary excretion data
  ✓ Chelation constant $K_C = 1E-10$
  ✓ 25% of chelation in liver
  ✓ Model prediction is dropping below unchelated baseline

- 1g DTPA / week
- 2x0.5 g DTPA / week
Case 0846 – New Analysis (Cont’d)

- Fitting daily urinary excretion and whole body data
  - $K_C = 1 \times 10^{-10}$ and 25% of chelation in liver
  - fit urinary excretion and whole body retention data
Case 0846 – New Analysis (Cont’d)

- Prediction of retention in organs
  - Predictions of retention in liver, skeleton and lungs
  - Acute inhalation of type M material is not a good choice
Case 0846 – New Analysis (Cont’d)

• Prediction of retention in organs
  ✓ Predictions of retention in liver, skeleton and lungs
  ✓ Acute inhalation of type M material is not a good choice

• The initial scenario needs to be refined
Summary

• The USTUR is unique resource for biokinetic modeling

• USTUR Case 0846
  ✓ Extensive data set is available
  ✓ Intake scenario is undefined
    ▪ Many assumptions are required for modeling
  ✓ Case 0846 contributed to education of students at KIT
    ▪ $\gamma$-measurement of 241Am in lung tissue samples
    ▪ MCNP simulations for HPGe detector calibration
Thank you for your Attention

Do you have any questions or suggestions on chelation therapy modeling? Bastian.breustedt@kit.edu is happy to receive and discuss them.

Five Decade Follow-up of Plutonium and Uranium Workers and hopefully many more decades to come.