USTUR Whole-Body Case 0212: Testing NCRP Wound Model

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Motivation

- >2,000 contaminated wounds reported
  - Commonly treated by tissue excision and chelation
- NCRP 156 Wound Model (2007)
  - Based exclusively on animal experiments
  - Important to test against human data
- Effectiveness of chelation treatment
  - Residual vs. projected dose
- USTUR Whole Body donations: A total of 42 cases
  - 10 cases with documented wound intakes: $^{239}\text{Pu}$ (9), $^{241}\text{Am}$ (1)
  - 4 cases with a single Pu wound as a major intake
  - Case 0212 selected for this study
USTUR Whole Body Case 0212

- Exposure: Wound (treated)
- Treatment: Tissue Excision & Ca-DTPA
- Donation Year: 1984
- Post-Intake: 17 y
- Cause of Death: Pulmonary Emphysema
- Age: 56 y
Contaminated Wound

- Left middle finger, anterior surface
- Cutting a pipe on the solvent extraction hood
- Material involved: $\text{Pu(NO}_3\text{)}_4$
- Initial survey meter reading: 10,000 dpm
  - Decontaminated to 500 dpm
- Initial wound count: 59 nCi (~2.2 kBq)
  - After wound excision: 11 nCi (~0.4 kBq)
  - Excised tissue count: 122 nCi (~4.5 kBq)
- Chelation treatment: 6 months – bi-weekly
  - A total of 26.5 g Ca-DTPA
Urinalysis Data

- Analysis Method:
  - Autoradiography
- MDA: ~0.001 Bq d⁻¹
- A total of 205 samples
Urinalysis Data: ‘Treated’

- **Analysis Method:**
  - Autoradiography
- **MDA:** \(~0.001\) Bq d\(^{-1}\)
- **A total of 205 samples**
- **180 samples**
  - affected by DTPA
  - 201 days post-intake
- **\(~916\) Bq Pu excreted during treatment**
  - Max rate: 73 Bq d\(^{-1}\)
Urinalysis Data: ‘Untreated’

- **Analysis Method:**
  - Autoradiography

- **MDA:** \(~0.001\) Bq d\(^{-1}\)

- **A total of 205 samples**

- **25 samples**
  - not affected by DTPA

- **Ave. post-DTPA rate:**
  - \(0.02 \pm 0.01\) Bq d\(^{-1}\)
Autopsy Tissue Sample Analysis

- Total of 264 tissue samples
- Analysis Method: *Alpha Spectrometry*

<table>
<thead>
<tr>
<th>Tissue</th>
<th>Concentration, Bq kg⁻¹</th>
<th>Activity, Bq</th>
</tr>
</thead>
<tbody>
<tr>
<td>Wound (muscle &amp; skin)</td>
<td>40.2 ± 0.7</td>
<td>14.3 ± 0.3</td>
</tr>
<tr>
<td>Lungs including LNTH</td>
<td>0.48 ± 0.07</td>
<td>0.82 ± 0.12</td>
</tr>
<tr>
<td>Skeleton (174 samples)</td>
<td>11.0 ± 0.1</td>
<td>114.5 ± 0.5</td>
</tr>
<tr>
<td>Liver</td>
<td>33.8 ± 1.1</td>
<td>80.5 ± 2.6</td>
</tr>
<tr>
<td>Kidneys</td>
<td>0.37 ± 0.01</td>
<td>0.172 ± 0.005</td>
</tr>
<tr>
<td>Soft Tissues (56 samples)</td>
<td>0.0004 ± 0.0001</td>
<td>34.2 ± 0.6</td>
</tr>
<tr>
<td>Total Systemic</td>
<td>n/a</td>
<td>229.2 ± 2.7</td>
</tr>
</tbody>
</table>
Methods

- Internal Dosimetry Software
  - IMBA Professional Plus®

- Maximum likelihood fitting of:
  - ‘Baseline’ (post-treatment) urine data

- Models applied:
  - ICRP 67 Pu Systemic Model
  - NCRP Wound Model
NCRP Wound Model

- Default material types:
  - Soluble
    - Weak
    - Moderate
    - Strong \( \Pu(NO_3)_4 \)
    - Avid
  - Colloid
  - Particle
  - Fragment

- Accidental Injection
  - Particles, Aggregates & Bound State
  - Trapped Particles & Aggregates
  - Colloid & Intermediate State
  - Soluble
  - Blood
  - Lymph Nodes
Results: Excretion

- Credible fit:
  - \( \chi^2 \) alpha = 0.246
Results: Retention

Pu Retention at Time of Death, Bq

<table>
<thead>
<tr>
<th>Organ</th>
<th>Predicted</th>
<th>Measured</th>
</tr>
</thead>
<tbody>
<tr>
<td>Liver</td>
<td>97.3</td>
<td>80.5</td>
</tr>
<tr>
<td>Skeleton</td>
<td>147.4</td>
<td>114.5</td>
</tr>
<tr>
<td>Wound</td>
<td>6.8</td>
<td>14.3</td>
</tr>
</tbody>
</table>

Model predicted:
- Pu in liver and skeleton
  - within ~25%
- Pu in wound
  - by a factor of 2
Results: Intake and Dose

- **Intake**
  - IMBA estimate: 364 Bq
  - Pu excreted with DTPA: 916 Bq
    - Total: 1,280 Bq

- **Committed Effective Dose**
  - Residual CED: 177 mSv
  - Projected CED: 622 mSv
Future Work

- Apply Bayesian analysis methods:
  - Define suitable priors for wound model parameters
  - Use Monte Carlo simulation (WeLMoS, MCMC) to:
    - derive best estimate of intake
    - calculate uncertainties in wound retention parameters
    - quantify effectiveness of DTPA treatment
Questions?