The 1976 Hanford Americium Accident
Then and Now

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On August 30, 1976 an americium-241 ion exchange column exploded in a Hanford Site waste management facility causing significant damage to the hood containing the column, extensive facility radiological contamination, and spraying an operator with highly contaminated nitric acid and debris. The worker underwent medical treatment for acid burns, as well as wound debridement, extensive personal skin decontamination and long-term DTPA chelation therapy for decorporation of americium-241. Because of the contamination levels and prolonged decontamination efforts, care was provided for the first three months at a unique emergency decontamination facility with gradual transition to the patient’s home occurring over another two months. The accident underwent an extensive investigation as to cause, response, lessons learned, therapy, and dosimetry, and has been well documented in numerous reports and journal articles. The room in which the accident occurred has been essentially isolated from entry since the accident, and only recently has effort begun to decontaminate and decommission the facility. This year 2011 marks the 35th anniversary of the accident. The lessons learned with regard to patient treatment and effectiveness of therapy still form the underlying philosophy of treatment for transuranic-contaminated injuries. Changes in infrastructure and facilities as well as societal expectations make for interesting speculation as to how responses might differ today.
The written version of this CEL is Chapter 23 in

*The Medical Basis for Radiation-Accident Preparedness: Medical Management*

- Proceedings of the 5th International REAC/TS Symposium, September 2011, Miami, Florida
- Ed. by Doran M. Christensen, Stephen L. Sugarman, and Frederick M. O’Hara, Jr.
- Published by ORAU, 2013, Oak Ridge, TN
The Accident – Aug 30, 1976 - ~3 a.m.

Plutonium Finishing Plant
Am Recovery Facility
The Accident Description

- Chemical explosion in an ion exchange column within a glove box.

- Explosion peeled open the column, blew out leaded glass windows and glove ports.

- Struck Harold McCluskey (age 64) in right side of face, peppered with glass shrapnel, concentrated nitric acid, resin beads, and $^{241}\text{Am}$.

- Chemical burns of face, eyes, neck and right shoulder.

- Lacerations with embedded foreign bodies.
The Accident – Aug 30, 1976
The Accident – Aug 30, 1976
Initial Response

- Helped from room by co-worker
- Nurse summoned
- Clothing removed and face, eyes, head, shoulders flushed with water
- Skin contamination levels exceeded alpha survey instrument’s highest scale
- Transported by ambulance to the Emergency Decontamination Facility (EDF), 25 miles away in Richland
Initial Treatment at EDF

- 1 g Ca-DTPA upon arrival
- Warm shower in EDF staff shower
- Transferred to surgery table/decon tub for debridement
- Bathed with mild liquid detergents
- Vigorous scrubbing not possible because of acid burns
- Direct alpha measurements not useful for monitoring decon progress – used smear/wipe approach and 19 skin check points to evaluate decon progress
Skin Decontamination
Skin Decontamination

Shower – Bathe – Scrub - Debride

- Twice daily baths for first week, then daily for 2 months
  - Ca-DTPA applied, rinsed off
  - Light scrubbing with mild liquid detergents

- Variations in decon reagents and techniques during first 2 weeks did not have significant impact on reduction

- From Day 10 on, reagents of choice were Schubert’s solution (tartaric acid, citric acid, DTPA, CaCl) and liquid (mild baby) shampoo

- Daily showers
Skin Decontamination

- Daily superficial debridement of face and neck for first 4 months removed scale, crusts, scabs, extruded foreign bodies (metal, plastic, cloth and glass), up to 0.5 cm

- Hair, eyebrows, arm hair, and whiskers analyzed

- Decontamination was extended, extensive, difficult and never complete.

- None of the attending team incurred recordable radiation dose or intake of radioactivity during the course of patient decontamination, treatment, and care.
Skin Decontamination
Contamination Measurements

Gamma Camera

1” × 1” NaI Detector
Contamination Measurements
Treatment – DTPA Therapy

- Ca-DTPA with Zn supplement for first 5 days
- Zn-DTPA beginning day 5 following expedited FDA approval as IND
- 583 g DTPA by slow push iv over 4 years with no side effects
- Considered life-saving
- Approach to DTPA therapy today is basically the same
Measurement of Liver, Bone, and Facial Tissue on $^{241}$Am Accident Subject Over 9.4 Year Period

Facial Tissue

Bone

Microcuries of $^{241}$Am

A - DTPA Daily
B - DTPA 3 Times/Week
C - No DTPA
D - DTPA Weekly
E - No DTPA
F - DTPA 2 Times/Month
G - No DTPA

Estimated Portion of Liver Content Attributed to $^{241}$Am in Bone. To get Actual Liver Content Subtract this Line from Total Liver Content.
Therapy

- Therapy limited systemic deposition to 13 μCi (500 KBq) instead of 500 μCi (19 MBq)

- Bone marrow aspiration on Day 16 was interpreted to be within normal limits.
Transition to Home

- Day 45 – recognized primary obstacle to release to home was concern for contamination spread from facial desquamation.

- Travel trailer to determine contamination problems associated with release to home. (Day 79 moved in)

- By late November was able to go into community and have Thanksgiving dinner with his family (Day 103)

- Nov/Dec – home during day. Return to trailer at night.

- January (5 months post accident) – released to home
Long-term Follow-up

- Monthly medical checks by Hanford occupational medicine staff
- Bioassay measurements (urine, feces, liver, skeleton, facial contamination)
- Mental attitude was excellent
- Reasonably healthy for 10 years, then multiple hospitalizations
- Aug. 17, 1987 - Death from congestive heart failure due to coronary heart disease (pre-existing to accident).
- Autopsy
  - No evidence of malignancy.
  - Tissues analyzed for dosimetry by US Transuranium Registry
Radiation Effects

Presence of $^{241}\text{Am}$ in face likely slowed healing of acid burns.

Significant depression of lymphocytes and platelets, but no clinical symptoms manifested.

Lymphocyte count returned to normal following unrelated treatment with heparin for thrombophlebitis.
Radiation Effects

Leukocyte concentrations in circulating blood (Filipy et al. 1995)
Radiation Effects

Neutrophil and lymphocyte concentrations in circulating blood (Filipy et al. 1995)
Radiation Effects

- Significant elevation of chromosome aberrations in lymphocytes in first year after accident and fluctuating thereafter. No direct relationship between aberration frequency and dosimetric parameters.

- Histopathology findings
  - Decreased cellularity of marrow
  - Extensive peritrabecular fibrosis
  - Lack of bone remodeling – possibly age-related

- Radiological effects relatively limited, but might have been more pronounced had exposure time been longer.
Other Effects

- Vision problems from nitric acid were most significant
  - Cataracts removed from left and right eyes (547-d and 1030-d post accident) were acid-induced rather than radiation.
  - Vision compromised by acid scarring of cornea (cornea transplant).
  - Mildly progressive photophobia

- Acid scarring

- No indications of malignancy.

- Gross and histopathology tissue examinations revealed no abnormalities other than those associated with existing pre-accident cardiovascular disease.
Post Mortem Tissue Analyses
McInroy, et al. (Health Phys. 69(3):318-323; 1995)

- 17 specific soft tissues – organ and skeleton
- Results ranged from 0.4 to 22 Bq-g\(^{-1}\)
- Highest soft tissue concentrations in liver, thyroid, cartilage, larynx, kidney,

<table>
<thead>
<tr>
<th>Tissue</th>
<th>Content (kBq)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Soft tissue (Liver)</td>
<td>55 (27.9)</td>
</tr>
<tr>
<td>Mineral bone (bone surfaces)</td>
<td>470</td>
</tr>
<tr>
<td>Bone Marrow</td>
<td>20</td>
</tr>
<tr>
<td>Total Body</td>
<td>545</td>
</tr>
<tr>
<td>Total (^{241}\text{Am Mass})</td>
<td>4.6 (\mu)g</td>
</tr>
</tbody>
</table>
Implications for Modeling

- Distribution consistent with previous USTUR case.

- Greater initial uptake by skeleton and soft tissue, less by liver, compared to then contemporary ICRP-30 and ICRP-48 models.

- Translocation had not occurred as expected.
  - Age-related? Radiation-related?

- Shorter liver half-time (7-y) compared to ICRP-30 (40-y) and ICRP-48 (20-y).
Dosimetry

- General agreement with Am biokinetic model
- Good agreement with 1993 ICRP 67 model
- Organ dose estimates (11-year cumulative)


<table>
<thead>
<tr>
<th>Organ</th>
<th>Absorbed Dose (Gy)</th>
<th>Equivalent Dose (Sv)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Bone</td>
<td>18</td>
<td>360</td>
</tr>
<tr>
<td>Bone Surface</td>
<td>510</td>
<td>10,200</td>
</tr>
<tr>
<td>Red Marrow</td>
<td>2.6</td>
<td>52</td>
</tr>
<tr>
<td>Liver</td>
<td>8</td>
<td>160</td>
</tr>
<tr>
<td>Lungs</td>
<td>1.6</td>
<td>32</td>
</tr>
<tr>
<td>Muscle</td>
<td>4.4</td>
<td>88</td>
</tr>
<tr>
<td>Effective</td>
<td>Not applicable</td>
<td>Not applicable</td>
</tr>
</tbody>
</table>

Estimated w/o DTPA:
- Bone dose ~ 25 Gy/year
- Liver dose ~ 1 Gy/day
Emergency Decontamination Facility - Then
Medical Decontamination Facility - Now
Medical Decontamination Facility - Now
Case Management

Team approach with consensus process was highly successful

<table>
<thead>
<tr>
<th>Role</th>
<th>Then</th>
<th>Now</th>
</tr>
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<tbody>
<tr>
<td>Patient</td>
<td>Integrally involved</td>
<td>(same)</td>
</tr>
<tr>
<td>Lead Care</td>
<td>Site Medical Director</td>
<td>Emergency Physician Hospitalist</td>
</tr>
<tr>
<td>Supporting medical</td>
<td>Private practice</td>
<td>Site medical staff, Private practice</td>
</tr>
<tr>
<td>Nurses</td>
<td>Site occ med staff</td>
<td>Hospital</td>
</tr>
<tr>
<td>Decon Team</td>
<td>Site rad pro, HP, nurse</td>
<td>Hospital volunteers</td>
</tr>
<tr>
<td>Rad Protection</td>
<td>Site HPs, techs</td>
<td>Hospital, Wash. State, &amp; site staff</td>
</tr>
<tr>
<td>Consulting &amp; Advising</td>
<td>HPs, radiobiologists, psychologist,</td>
<td>Same &amp; REAC/TS</td>
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</table>
Media Communications - major effort

• Wide public interest
• Provide accurate info
• Protect patient privacy
Health Physics
Oct. 1983

Guideposts

Reader’s Digest
April 1981
- Increased tension today
- Internet & social media
- Instant experts
- Demand for more information sooner
Conclusions

- Not much different today regarding decontamination, DTPA therapy, radiological measurements.

- Major change in facilities and medical management infrastructure.

- Increased expectations in communication with public.

- The medical treatment administered allowed him to live a reasonably normal life.
Conclusions

- None of the attending team incurred recordable radiation dose or intake of radioactivity during the course of patient decontamination, treatment, and care.

- The accident was tragic.
- The response heroic.
- The outcome ... probably the best that could be expected on all fronts.

- A remarkable accomplishment... and still achievable.
Bibliography


- *Health Physics*, October 1983

- *Health Physics*, September 1995
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Ron Kathren  Karen Phillips, MD
Dick Toohey

And a host of others

(* deceased)
Dedication to the Ideal Patient
Harold R. McCluskey (1912 – 1987)
“The Atomic Man”