The 1976 Hanford Americium Accident Then and Now

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Abstract

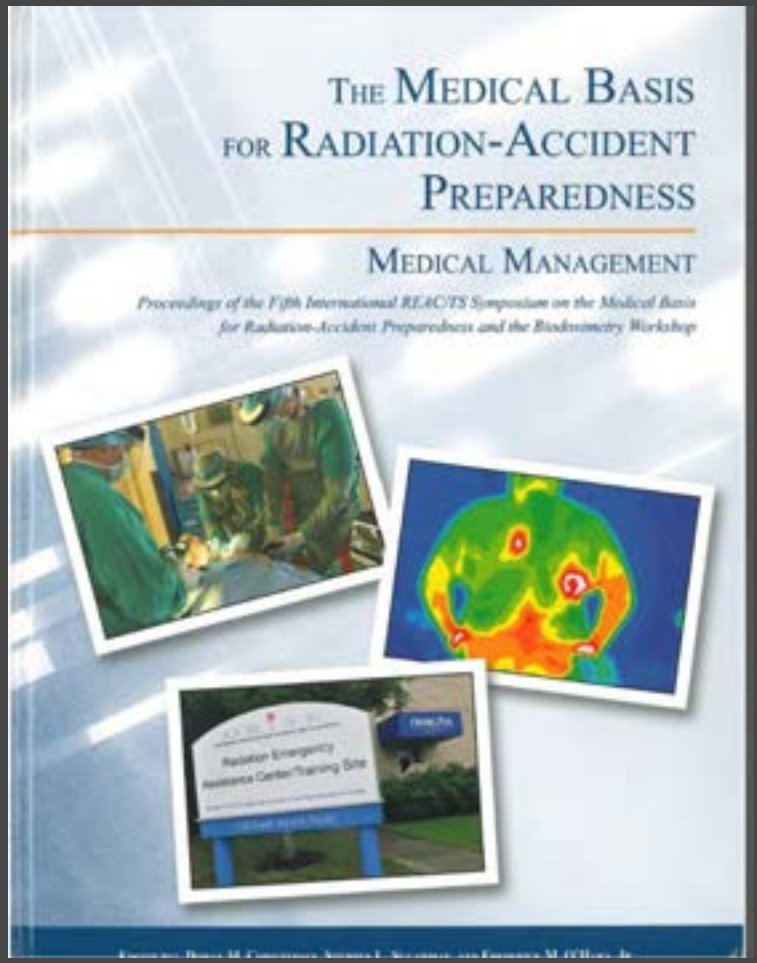
On August 30, 1976 an americium-241 ion exchange column exploded in a Hanford Site waste management facility causing significant damage to the hood containing the column, extensive facility radiological contamination, and spraying an operator with highly contaminated nitric acid and debris. The worker 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.

For the Record…

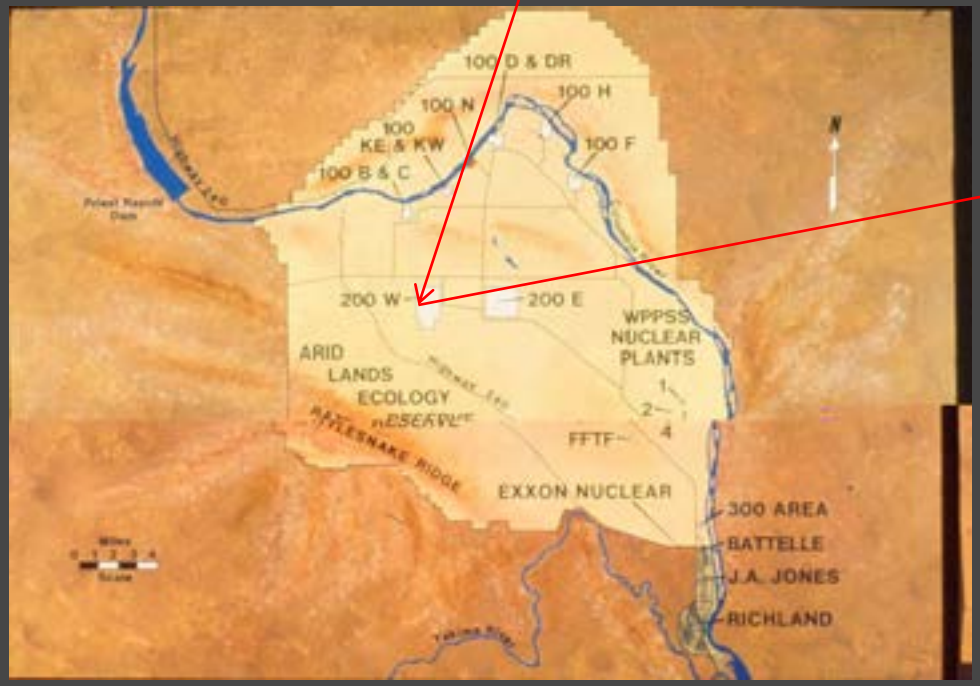
The written version of this CEL is Chapter 23 in

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.

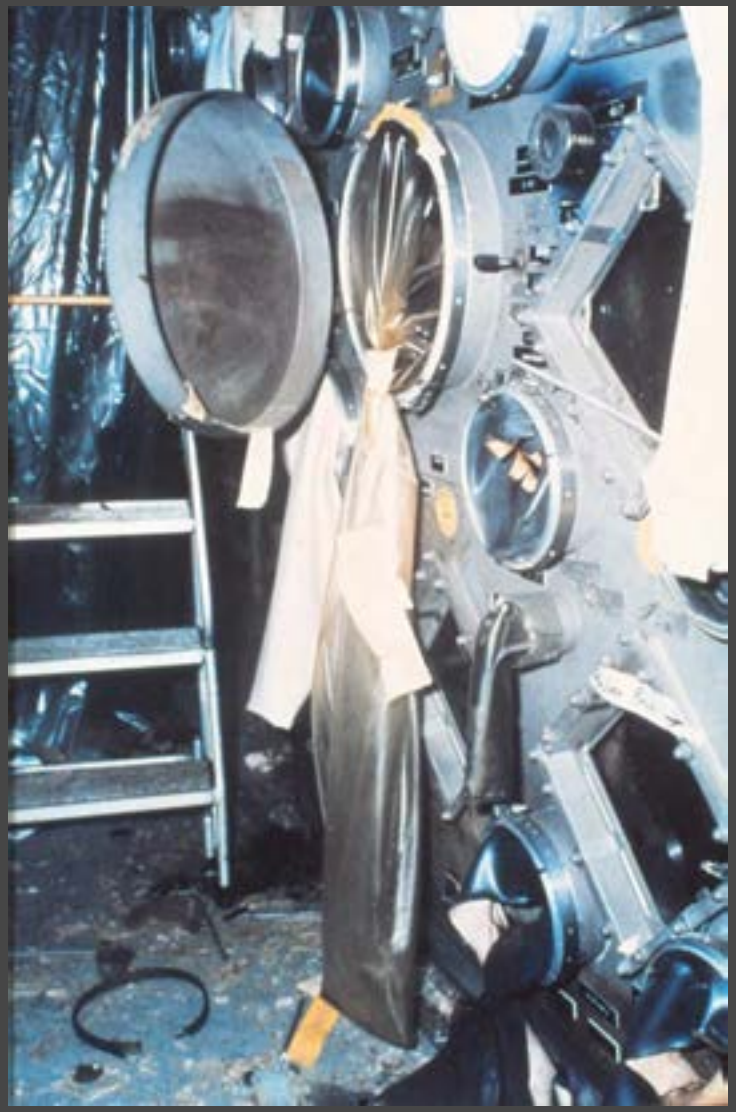


Plutonium Finishing Plant
Am Recovery Facility

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}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

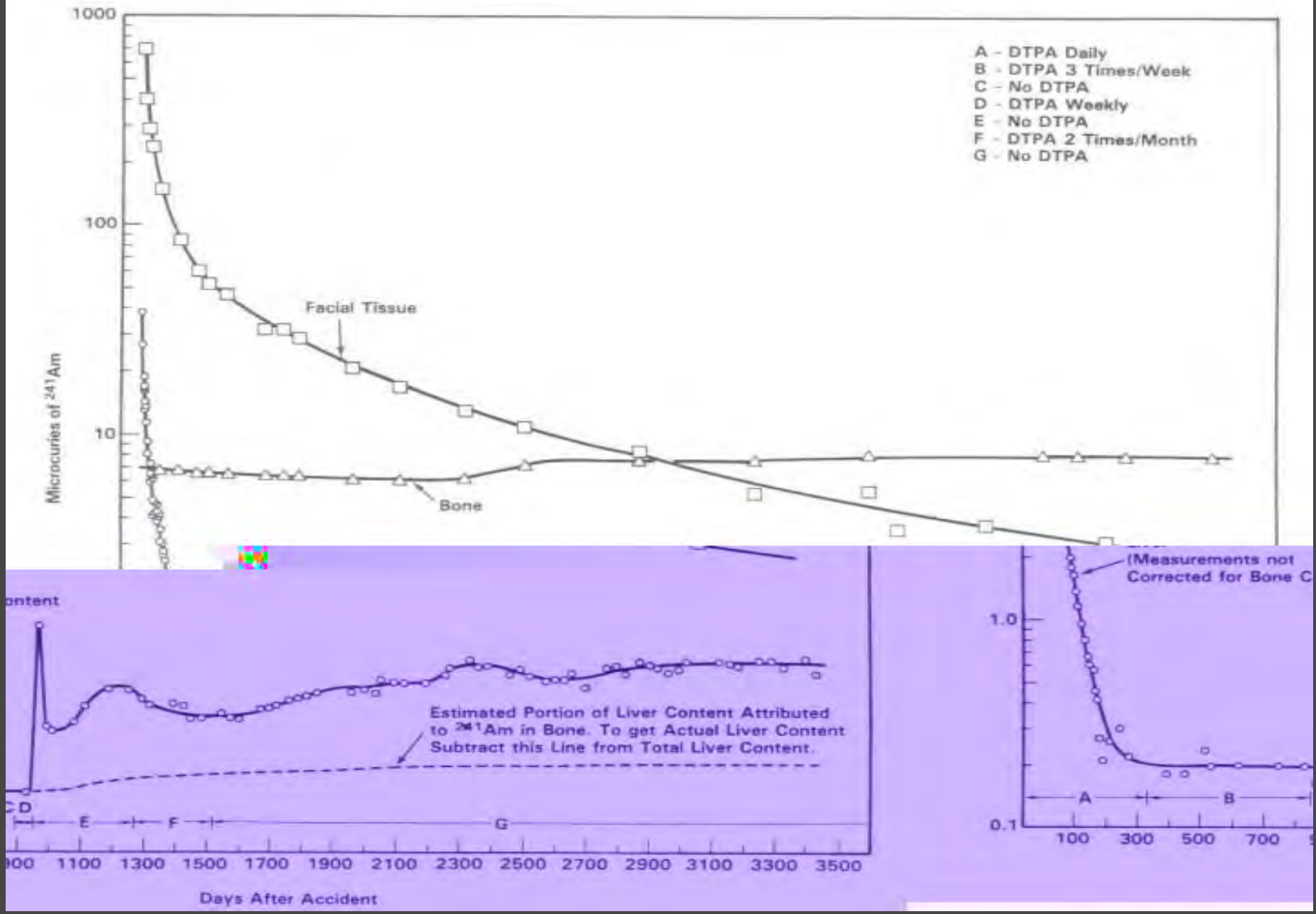
1” × 1” NaI Detector

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



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

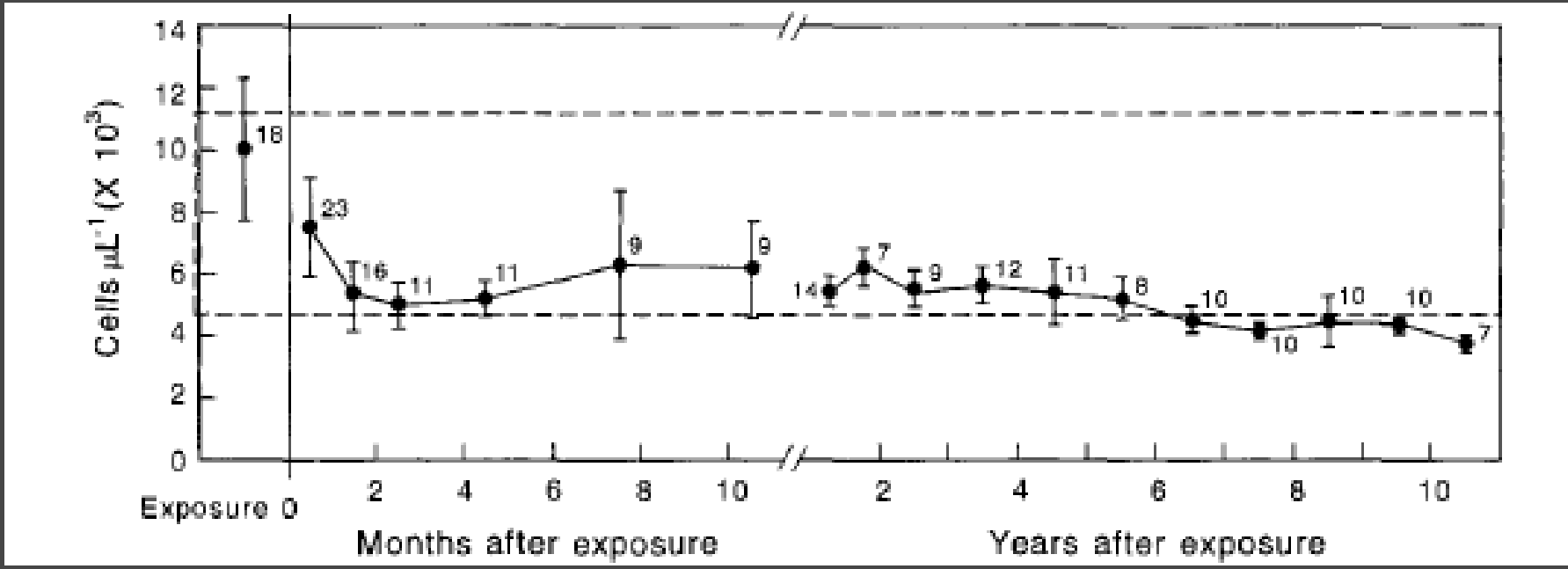
- Monthly medical checks by Hanford occupational medicine staff
- Bioassay measurements (urine, feces, liver, skeleton, facial contamination)
- Mental attitude was excellent
- Reasonably healthy for 10 years, then multiple hospitalizations
- Aug. 17, 1987 - Death from congestive heart failure due to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

Radiation Effects

- Presence of ^{241}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.

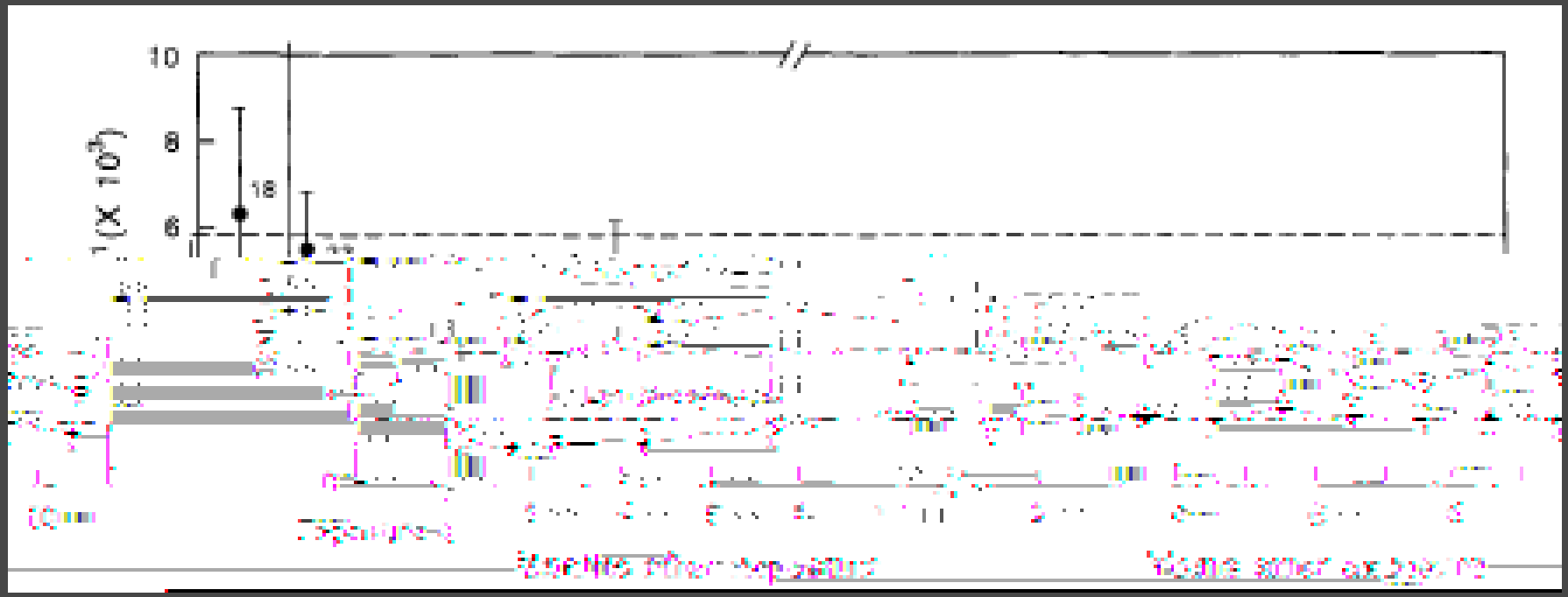
Radiation Effects

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, cartilege, larynx, kidney,

Tissue	Content (kBq)
Soft tissue (Liver)	55 (27.9)
Mineral bone (bone surfaces)	470
Bone Marrow	20
Total Body	545
Total ^{241}Am Mass	4.6 µg

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)

  Toohey and Kathren, *Health Phys. 69(3):310-317; 1996.*

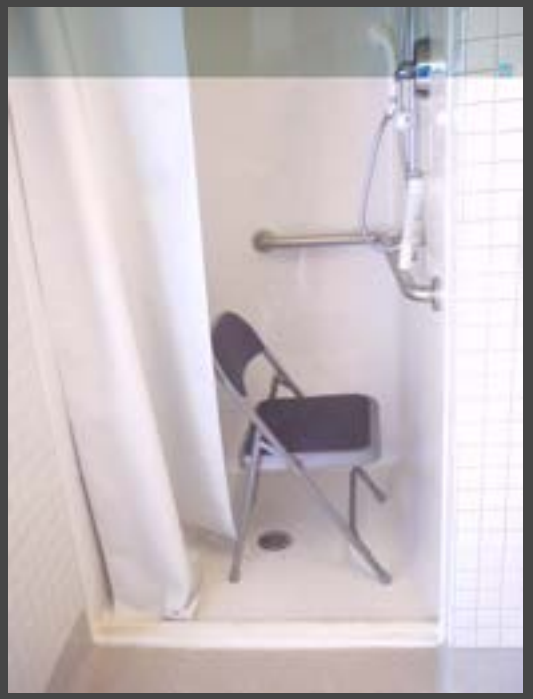
Organ	Absorbed Dose (Gy)	Equivalent Dose (Sv)
Bone	18	360
Bone Surface	510	10,200
Red Marrow	2.6	52
Liver	8	160
Lungs	1.6	32
Muscle	4.4	88
Effective	Not applicable	Not applicable

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



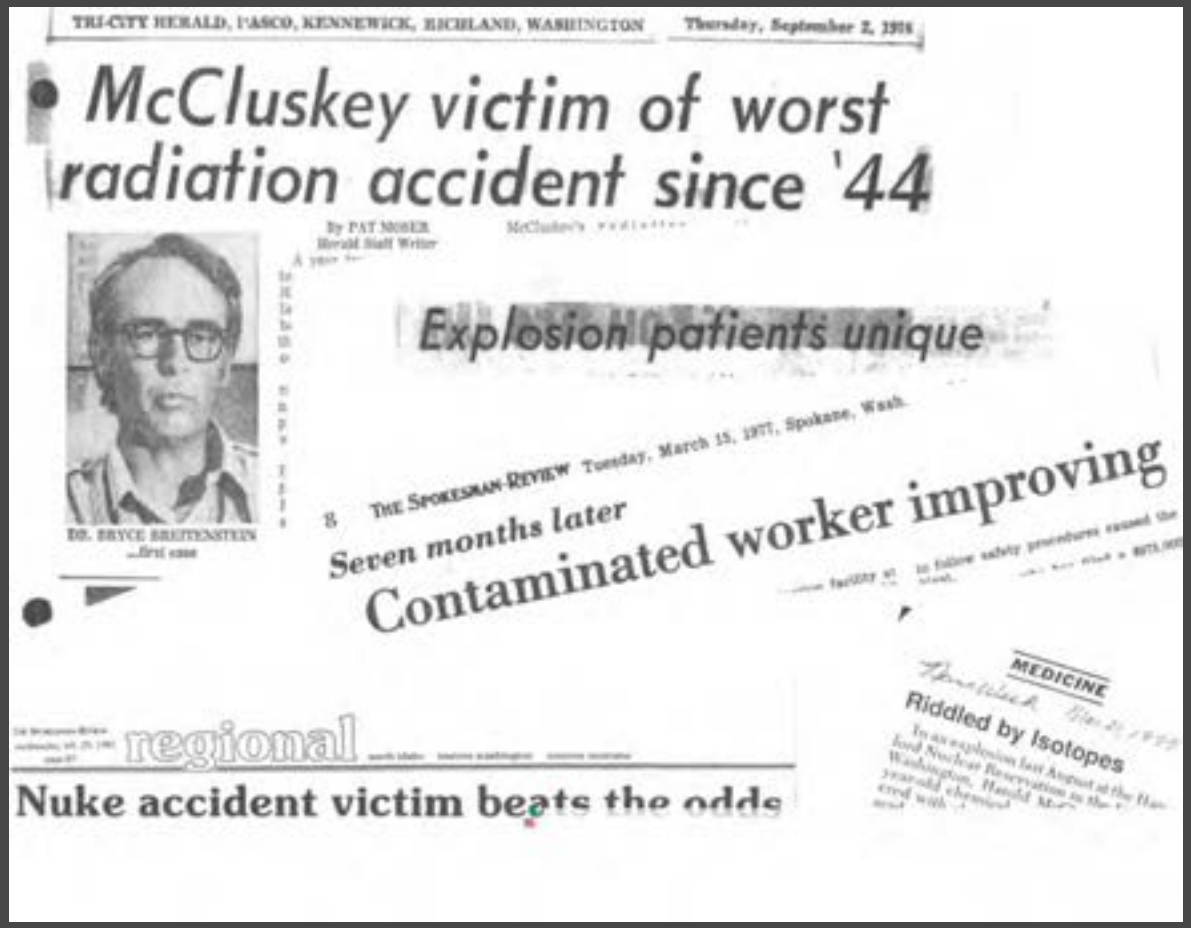
Case Management

Team approach with consensus process was highly successful

	Then	Now
Patient	Integrally involved	(same)
Lead Care	Site Medical Director	Emergency Physician Hospitalist
Supporting medical	Private practice	Site medical staff, Private practice
Nurses	Site occ med staff	Hospital
Decon Team	Site rad pro, HP, nurse	Hosptial volunteers
Rad Protection	Site HPs, techs	Hospital, Wash. State, & site staff
Consulting & Advising	HPs, radiobiologists, psychologist,	Same & REAC/TS

Media Communications- major effort

- Wide public interest
- Provide accurate info
- Protect patient privacy



TRI-CITY HERALD, PASCO, KENNEWICK, RICHLAND, WASHINGTON Thursday, September 2, 1976

McCluskey victim of worst radiation accident since '44

By PAT MOSER
Herald Staff Writer

DR. BRYCE BREITENSTEIN
...first case

Explosion patients unique

THE SPOKESMAN-REVIEW Tuesday, March 15, 1977, Spokane, Wash.

Seven months later

Contaminated worker improving

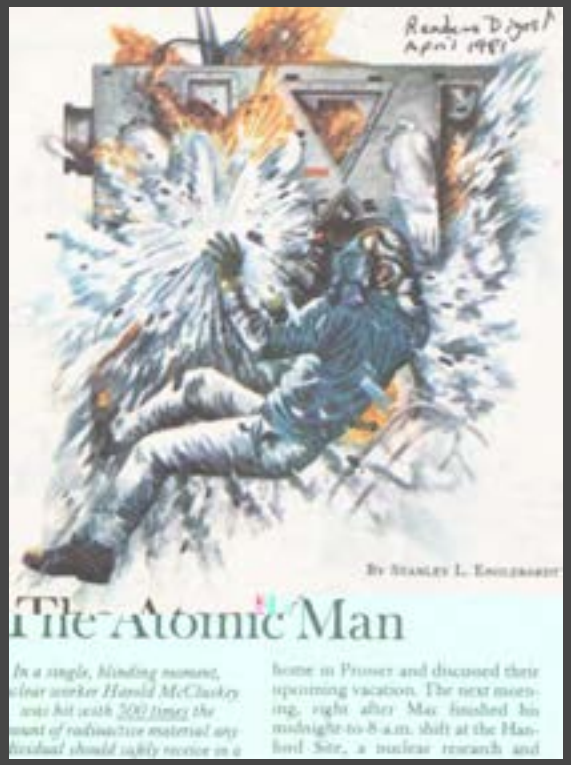
MEDICINE

Riddled by Isotopes

regional

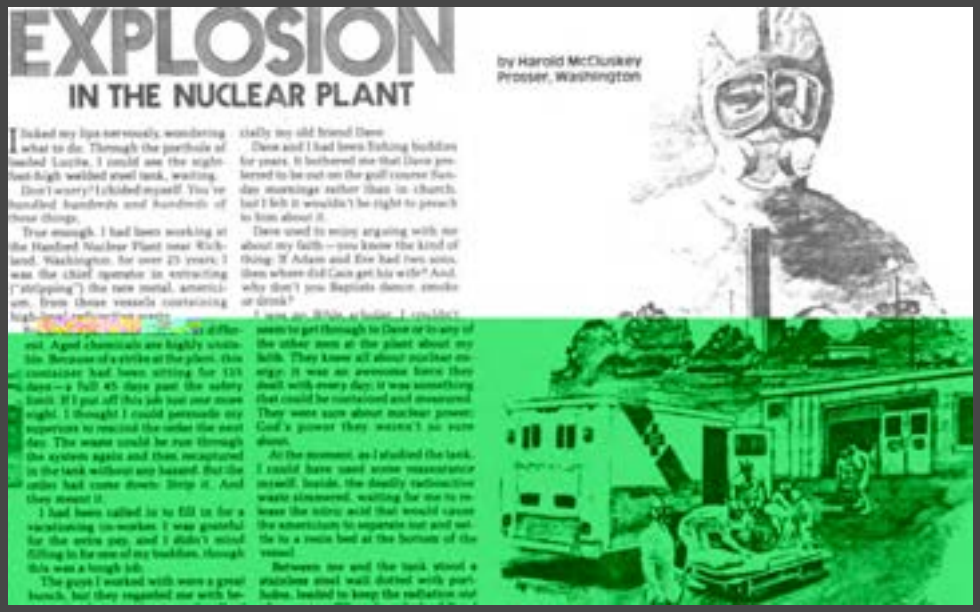
Nuke accident victim beats the odds

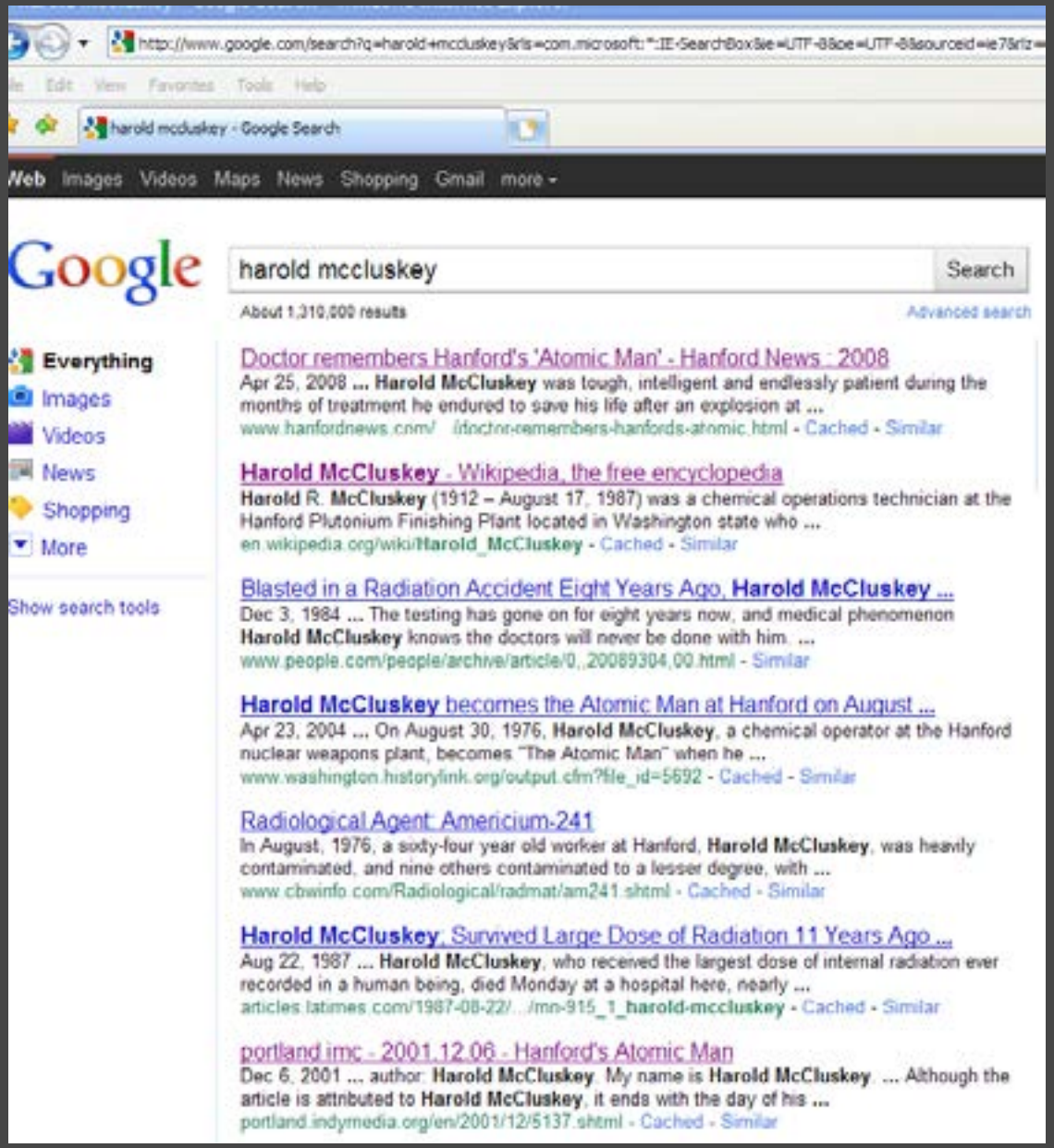
Health Physics
Oct. 1983



Reader's Digest
April 1981

Guideposts
Oct. 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

- This talk: Chapter 23 of *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., ORAU, 2013.
- *Health Physics,* October 1983
- *Health Physics,* September 1995

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Karen Phillips, MD

And a host of others

(* deceased)

Dedication to the Ideal Patient
Harold R. McCluskey (1912 – 1987)
"The Atomic Man"