

Radiological Terrorism: Clinical and Public Health Aspects

**Satellite Conference
Thursday, March 16, 2006
12:00-1:30 p.m. (Central Time)**

**Produced by the Alabama Department of Public Health
Video Communications and Distance Learning Division**

Disclosure

- The opinions expressed by the speakers are not necessarily shared by the Centers for Disease Control and Prevention.

Faculty

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Objectives

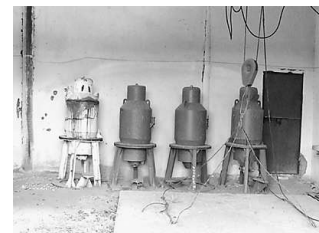
- Delineate the types of radiation incidents
- Review basic principles of radiation physics
- Discuss clinical consequences of radiation injury

Objectives

- Review historical incidents
- Set up plans for public health response, hospital decontamination and performance of radiation detection safely
- Discuss available therapeutic measures for radiation injuries



**Recovered
transport
container**



**Sources used in
mobile irradiators
containing 3500
Curies of Cs-137
(Former Soviet Union)**

Types of Threats

- Radioactive dispersal device including the “Dirty Bomb” (RDD) scenario
- Simple radiological device
- Nuclear weapon detonation
- Improvised nuclear device (IND)
- Nuclear power plant accident

Goiânia Incident: RDD

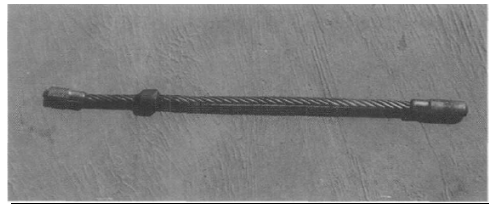


2. The derelict radiotherapy clinic in Goiânia from which the caesium source was taken.

Goiânia Incident



Simple Radiological Device



Nuclear Weapon Detonation

- August 1945
- Hiroshima: Little Boy made of Uranium (15 KT)
- Nagasaki: Fat Man made of Plutonium
- Damage and mortality secondary to Nuclear weapon detonation:
 - Thermal blast (35%)
 - Radiation (15%)
 - Shock (50%) Contamination from radioactive fallout

Nagasaki, 1945



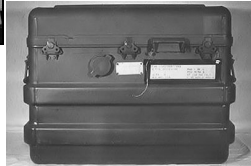
Pre and Post



Improved Nuclear Device (IND)



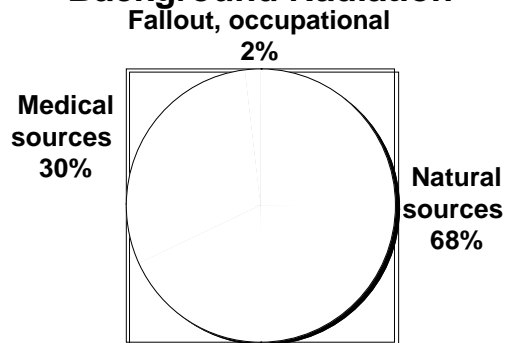
Chairman Dan Burton
Committee –
Demonstration of
example
“suitcase nuke”



Nuclear Plant Incident



Background Radiation



Ionizing Versus Non-ionizing Radiation

- Non-ionizing radiation (microwaves, UV): does not interact with other atoms
- Ionizing radiation interacts with human body through direct and indirect effects:
 - *Directly* interacts with critical biological molecules in human cell such as DNA
 - *Indirectly* interacts with cell water to produce toxic free radicals

Fundamental Principles of Radiation Protection in Whole Body Exposure

Time

Distance

Shielding

Radiation Damage by Two Effects

- 1) Deterministic effect
 - Dose determines effect
 - Must exceed threshold dose
 - Examples: Acute radiation sickness (ARS)
Local radiation injury (LRI)

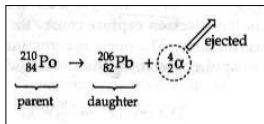
Radiation Damage

- 2) Stochastic effects
 - Random variability and probability

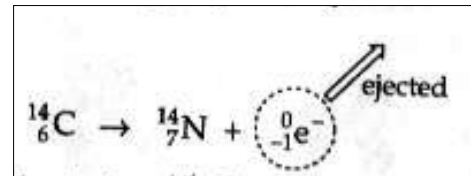
Two Types of Radiation Hazards

1. Body exposure:
 - Partial body exposure
 - Whole body exposure
2. Contamination:
 - External skin contamination
 - Internal contamination (from ingestion or inhalation or from open wounds)
 - Skin absorption is not clinically significant

Types of Ionizing Radiation: Alpha Particles



Types of Ionizing Radiation: Beta Particles



Types of Ionizing Radiation: Gamma Rays

- Gamma rays
 - Electromagnetic waves
 - Gamma rays are similar to x-rays
 - Are a significant external hazard (depending on duration of exposure, distance from the source, and type of shielding)

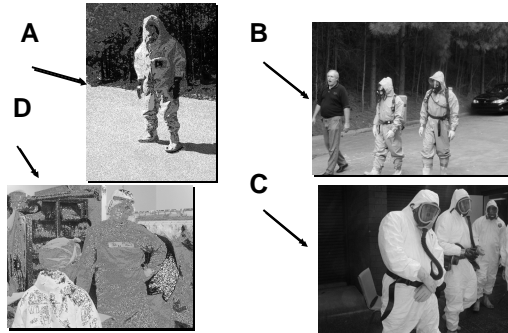
Types of Ionizing Radiation

- Neutrons – secondary ionization
 - Uncharged. Causes whole body irradiation like Gamma rays.
 - Emitted from fission reactions such as during a nuclear detonation, a nuclear reactor or criticality accident.

Radiation Units

- **RAD=**
- **REM=**
- **SI corresponding units:**
 - **RAD=Gray**
 - **REM = Sievert**

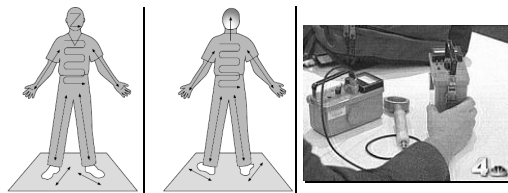
PPE



Personal Protection

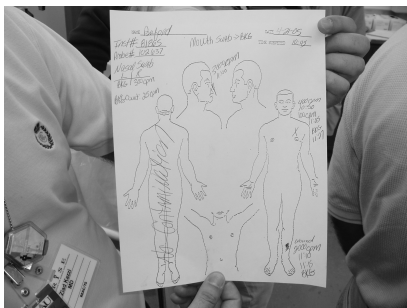


Radiation Detection



REAC/TS and CDC

Radiation Survey



Decontamination

- **Soap and water**
- **Decontamination should proceed in a centrifugal manner**

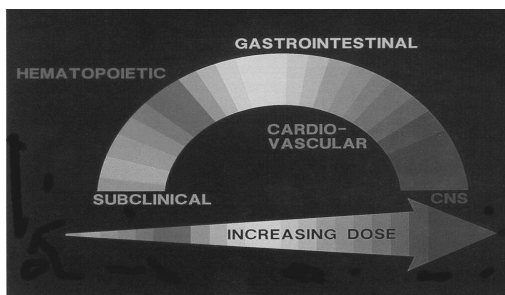
Decontamination

- Perform systematic patient (and personnel afterwards) decontamination.

Clinical Syndromes

- Acute Radiation Syndrome
- Internal Contamination
- Local Radiation Injury

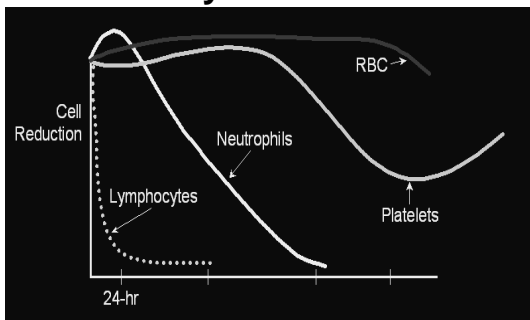
Acute Radiation Syndrome (ARS)



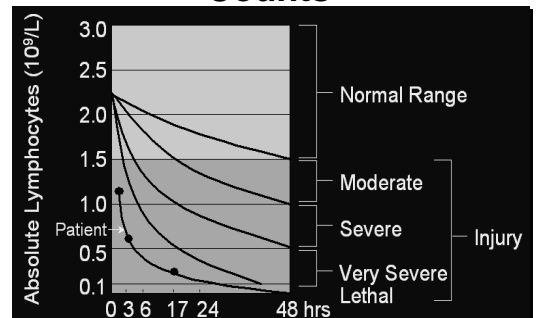
ARS: Prodrone

Dose Estimate	Victims with Vomiting	Time to Onset of Vomiting
Gy	%	H
0	-	-
1	19	
2	35	4.63
3	54	2.62
4	72	1.74
5	86	1.27
6	94	0.99
7	98	0.79
8	99	0.66
9	100	0.56

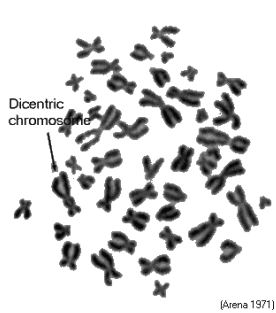
ARS: Hematopoietic Syndrome



ARS: Absolute Lymphocyte Counts



ARS: Hematopoietic Syndrome



ARS: Hematopoietic Syndrome

- **Complications:** infection and bleeding
- **Treatment is supportive:**
 - Blood products
 - Antibiotics
 - Colony stimulating factors such as filgrastim or G-CSF (Neupogen®) available in the SNS
 - Allogenic transplant

Internal Contamination

Radionuclide	Medication
Iodine	KI (potassium iodide)
Transuranics such as Plutonium & Americium	Zn-DTPA Ca-DTPA
Uranium	Bicarbonate
Cesium Rubidium Thallium	Prussian Blue* [Ferrihexacyano- Ferrate(II)]
Tritium	Water

Radioactive Iodine Exposure Treatment

- **Iodine Prophylaxis and Treatment**
 - Potassium iodide (KI) is an effective, inexpensive thyroid-blocking agent.

Transuranics



Cesium-137

Table 2: Cesium-137 Effective Half-life During and After Treatment with Insoluble Prussian blue
(In Days, by Age, and Dose of Insoluble Prussian blue)

Group	Age (Years)	Insoluble Prussian blue dose (grams/day)	No. of Pts.	During Insoluble Prussian blue Treatment - $^{137}\text{Cs T}_{1/2}$	Off Insoluble Prussian blue Treatment - $^{137}\text{Cs T}_{1/2}$
Adults	> 18	10	5	26 ± 6 days	80 ± 15 days (all 21 adult patients)
Adults	> 18	6	10	25 ± 15 days	
Adults	> 18	3	6	25 ± 9 days	
Adolescents	12-14	< 10	5	30 ± 12 days	62 ± 14 days
Children	4-9	< 3	7	24 ± 3 days	42 ± 4 days

Yanango, Peru. Feb 20,1999

- Iridium source loss
- Picked up by worker and put in his back pocket
- The patient developed severe radiation burn in his pelvic area as well as ARS
- He survived with significant disability

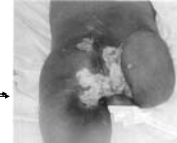
Yanango - Peru May and December,1999

Patient treated
in France

May 1999



December 1999

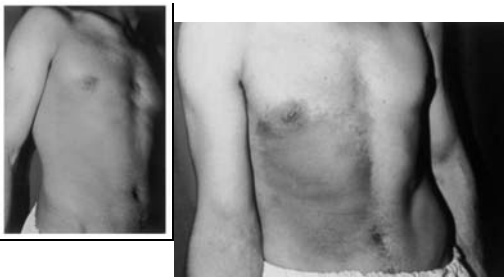


Local Radiation Injury

- May occur with or without ARS
- Deterministic effect
- Complications may be delayed
- Management includes pain control, antibiotics and surgery
- Hyperbaric oxygen therapy

Local Radiation Injury

- May be divided into 5 types:
 - Epilation
 - Erythema
 - Dry desquamation
 - Wet desquamation
 - Necrosis



Worker in Iran who placed an Iridium source
in his coat pocket for two hours

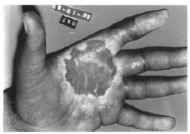
Moist Desquamation



23. Large bulla on palmar surface of the hand. Note wet desquamation.

Patient from Goiania
Incident (IAEA)

Moist Desquamation



20. Severe blistering and peeling of the skin on the palm and fingers.



21. Severe blistering of the skin on the palm and fingers.



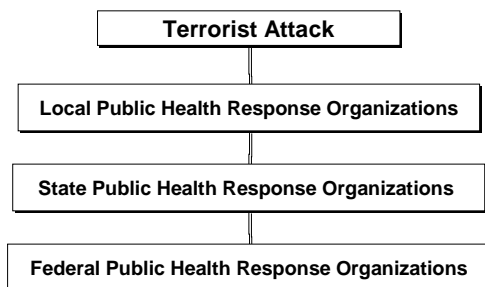
Photo 12. Blistering of the right hand (palm surface of the 2nd, 4th, 6th and 5th fingers) (17 April 1995).

Necrosis



Desquamation and skin necrosis 21 days after exposure. Note: the white areas correspond to silver ointment.

All Emergencies Are Local



The National Response Plan

National Response Plan
December 2004



Nuclear/Radiological Incident Annex

- Department of Homeland Security coordinates the Federal response to radiological incidents of national significance
- Department of Justice has lead responsibility for criminal investigations
- Coordinating Agency is determined by the type of emergency
- Department of Health and Human Services is a cooperating agency

State and Local Public Health Response

- Monitor workers' health and safety
- Assure safe shelters and healthy food and water supplies
- Coordinate sampling and laboratory analysis of samples

State and Local Public Health Response

- Field investigations and monitoring of people including creation of registries
- Criteria for entry and operations at the incident site
- Disease control and prevention measures

Medical Support

- Evaluate health and medical impacts on the public and emergency personnel
- Develop medical intervention recommendations
- Treat impacted citizens
- Request Strategic National Stockpile

More Information

- CDC Radiation Emergencies
www.bt.cdc.gov/radiation
- Department of Homeland Security
www.dhs.gov
- Environmental Protection Agency
www.epa.gov/radiation
- Nuclear Regulatory Commission
www.nrc.gov/what-we-do/radiation.html
- Conference of Radiation Program Control Directors
www.crcpd.org