Radiological Dispersal Device &
Nuclear Detonation

EXPLOSION AND BLAST INJURIES

Scenario Presentation

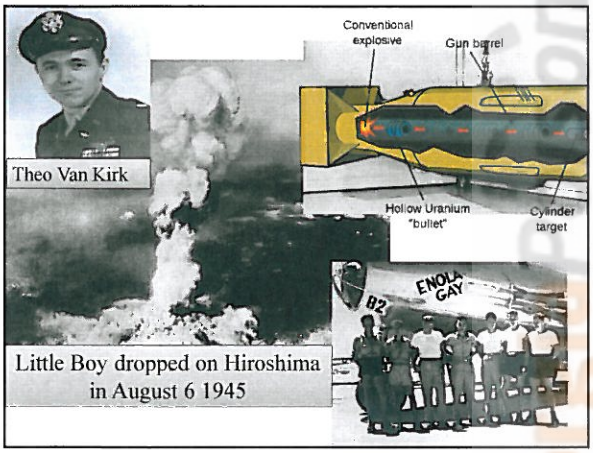
Possible Scenarios

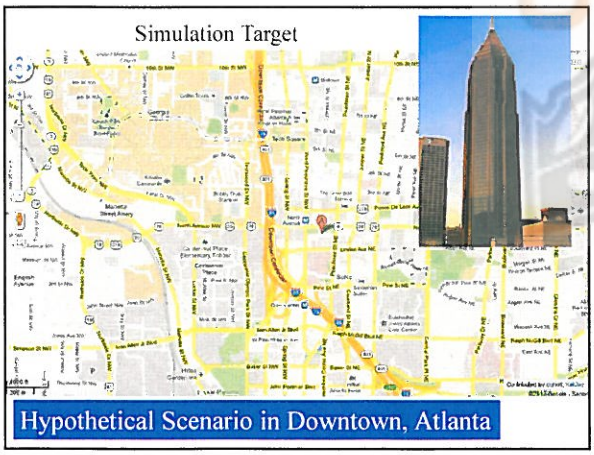
- Radiological Exposure Device
- Improvised nuclear device (IND)
- Nuclear weapon detonation
- Nuclear power plant accident
- Radioactive dispersal device (RDD) including the "Dirty Bomb" scenario

Photo Credit Sandia National Laboratories and Wikipedia

"Dirty Bomb"

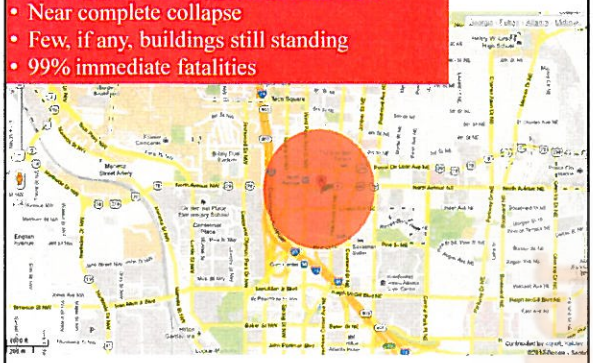
- Conventional explosive + radioactive material =
  "dirty bomb"
- Dispersal pattern variable
- Combined blast and burn injuries
- External and internal contamination
- Potentially large population affected





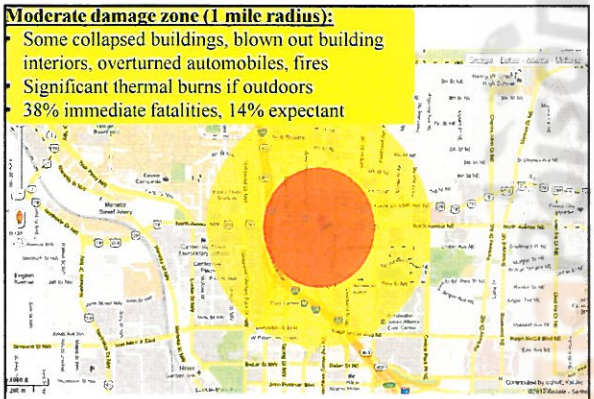
Severe damage zone (0.5 mile radius):

- Near complete collapse
- Few, if any, buildings still standing
- 99% immediate fatalities



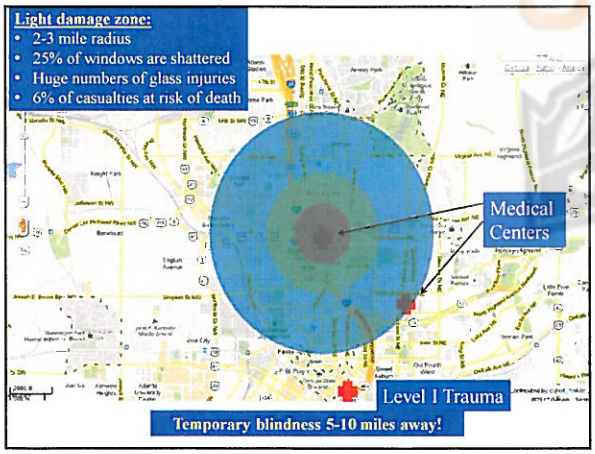
Moderate damage zone (1 mile radius):

- Some collapsed buildings, blown out building interiors, overturned automobiles, fires
- Significant thermal burns if outdoors
- 38% immediate fatalities, 14% expectant



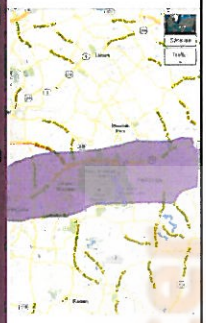
Light damage zone:

- 2-3 mile radius
- 25% of windows are shattered
- Huge numbers of glass injuries
- 6% of casualties at risk of death



Dangerous Fallout Zone or Dangerous Radiation Zone:

- Extends 25 miles downwind of ground zero
- Reaches maximum extent at 1 hr
- Severely hazardous fallout will descend to the ground within a few hours and may shrink to a few miles in a couple of days (decay)
- Mostly visible to naked eye (grains of sand)
- Exposure rate >10 R/h



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Casualties (10 kT model)

- For large city with 2 million population
  - 230,000 immediate fatalities
  - 323,000 injured survivors
    - 99,000 will succumb without medical treatment
    - 73,000 will still succumb with medical treatment
    - **26,000 can be saved with medical treatment**

Acute Injuries after a Nuclear Detonation

- Blast injuries
  - Blast wave can take several seconds to travel a few miles
  - Glass injuries (within a few miles)
  - Duck and Cover can protect people if they see the bright flash of light (can be seen up to 100 miles away)
    - May not be possible in a ground burst inside a city
- Thermal burns injuries
  - Primary flame (fireball up to few miles away)
  - Secondary fires

Acute Injuries after a Nuclear Detonation

- Radiation injuries
  - Prompt radiation (within first minute)
  - Latent (after first minute)
    - Emitted from the fallout
      - Composed of fission products and neutron activation products
  - Acute Radiation Syndrome
  - Beta burns

Acute Injuries after a Nuclear Detonation

- Combined injuries (estimated to occur in 60%)
- Flash blindness (up to 6 miles)
- Electromagnetic pulse (EMP)
  - No direct health effects
  - High voltage surge in conductors
  - Poorly characterized in an IND
  - Probably not beyond 2 miles of ground zero

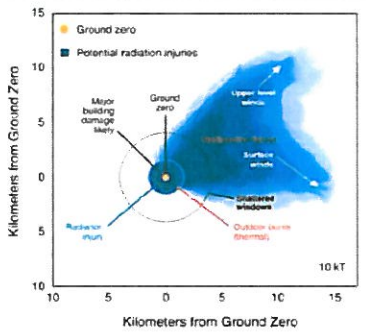


Fig. 6.1. Nuclear terrorism incident damage and fallout pattern. Significant differences in fallout patterns can result from varying wind directions and speeds at varying altitudes (Buddemeier and Dillon, 2009)

Source NCRP Numb

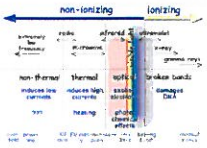
Long Term Effects

- Delayed Effects of Acute Radiation Exposure (DEARE)
  - Pulmonary fibrosis
- Solid tumors
- Leukemias

MECHANISM OF DISEASE

Ionizing Versus Non-ionizing Radiation

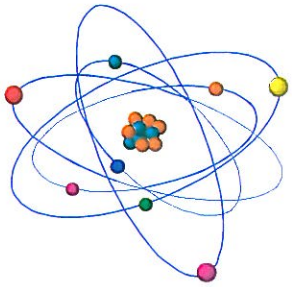
- Ionizing radiation interacts with human body through direct and indirect effects
  - Directly
  - Indirectly
- Non-ionizing radiation (microwaves, UV)
  - Does not ionize other atoms or lead to the formation of free radicals



Radiation Damage

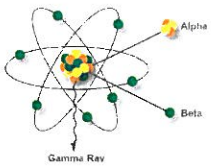
- Deterministic
  - Threshold dose
  - Local radiation injury
  - Acute radiation syndrome
- Stochastic
  - Random
  - Oncogenensis
  - Teratogenesis

Radiation Physics 101

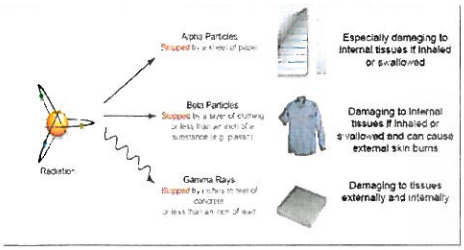


Radioactive Decay

- Atoms decay to reach a more stable state by emitting inonizing radiation in the form of particles or penetrating radiation (Gamma rays).



Different Types of Radiation



Types of Ionizing Radiation

Radiation Units: S.I. Versus USA

S.I.	Formula	USA
1 Gray (Gy) =	100 x	RAD
1 Sievert (Sv) =	100 x	REM

2 Different yet Possible Overlapping Entities

- Exposure
  - Whole body
  - Partial body
- Contamination
  - External
  - Internal

Radiation Protection in Whole Body Exposure

Time

Distance

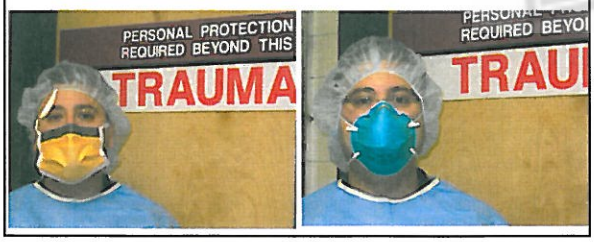
Shielding

Pick the Appropriate Personal Protective Equipment (PPE)!

WHEN CARING FOR THESE PATIENTS

Respiratory Protection

- Commonly available protective masks are generally sufficient pre-decontamination
- OSHA/NIOSH Hospital staff taking care of patients in the pre-decontamination and decontamination areas, PAPRs or HEPA filter negative pressure masks are described as minimum

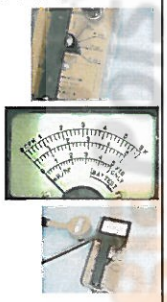


Personal Protection

- Standard Precautions

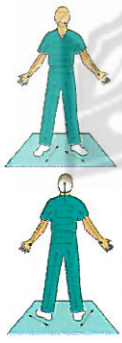
Radiation Detection in the ED

- Victims should be surveyed with Geiger-Muller counters.

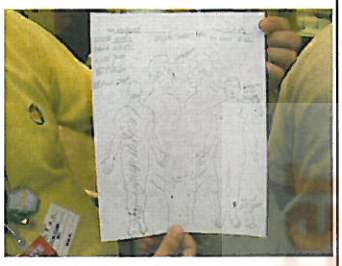


Radiation Detection in the ED

❖ Survey patient for radiological contamination and mark areas on body diagram.
❖ Remove contaminated clothes and label them.
❖Except for an instance of highly-radioactive shrapnel, contamination should NOT deter medical staff from treating life-threatening injuries.



Radiation Survey in the ED and Decontamination



DIAGNOSIS OF INTERNAL CONTAMINATION

In Vivo Measurements

- Whole body counters
- Chest counters for Plutonium and Uranium
- Wound monitoring instruments

Whole Body Dosimetry

- Using whole body counters or scanners that are potentially available at nuclear medicine departments.
- It is crucial to know when the contamination occurs as well as which radionuclide is involved.

www.bt.cdd.gov/radiation/clinicians/evaluation/index.asp

Diagnosis By Excretion (Bioassay) Sampling

- Collect urine or feces to measure excretion rates
- Challenging interpretation
  - Time when contaminationoccured
  - Charcteristics of inhaled or internalized radionuclides

Internal Contamination
Acute Radiation Syndrome

CLINICAL IMPACT AND CONSEQUENCES

Clinical Consequences of Internal Contamination

- Acute and subacute
  - End organ dammage
  - Acute Radiation Syndrome
  - Multiorgan failure
- Chronic
  - Solid tumors
  - Leukemias

Management Strategies

- Supportive care
- Decreasing absorption
- Decorporation and enhance elimination
- Long term monitoring

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

Transuranics

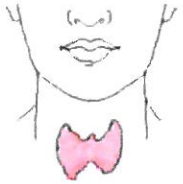
- Used for Transuranics such as Plutonium and Americium
- First dose should be Calcium DTPA followed by Zinc DTPA
- Duration of therapy will be guided by urine or feces transuranic concentrations

Cesium-137

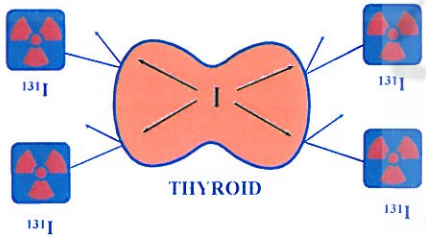
- 46 Goiania pts contaminated with Cs-137 treated with Prussian Blue
- Less than 1% is absorbed
- Exchanges a cation and binds Cesium or Thallium
- Decreases GI absorption and interruts enterohepatic circulation

Radioactive Iodine Exposure

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



Radioactive Iodine Exposure

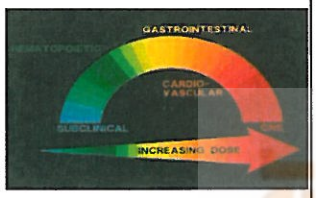


Saturate the Critical Organ with the Stable Isotope

ACUTE RADIATION SYNDROME (ARS)

Acute Radiation Syndrome (ARS)

- Deterministic effect
- Prodrome phase
- Hematopoetic syndrome
- Gastrointestinal syndrome
- CV/CNS syndrome



Prodrone

- Vague Sx: nausea, vomiting, headache.
- Help predict the dose: the higher the absorbed dose the earlier and the more frequent the Sx occur.

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

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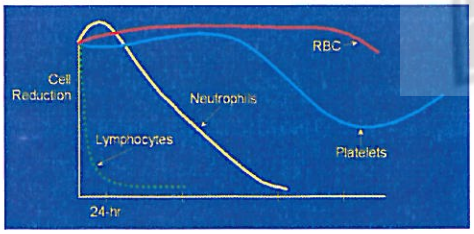
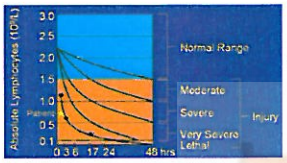
Hematopoetic Syndrome (2-6 Gy)



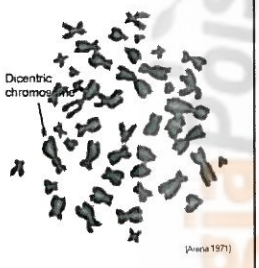
Lymphocyte Depletion Kinetics

- Andrew's nomogram helps estimate the dose of radiation.
- WBC with differential every 6 hrs for first 24-48 hours.



Cytogenetics

- Rate of dicentric chromosomes in peripheral lymphocytes.
- Available at REAC/TS.
- Takes a few days.



Management of the Hematopoetic Syndrome

- Complications: infection and bleeding.
- Treatment is supportive:
  - Reverse isolation
  - IVF
  - Blood products
  - Antibiotics
  - Colony stimulating factors such as filgrastim or G-CSF (300 mcg s/c per day)
  - Stem cell transplant

Population Monitoring

- The process to screen people for radioactive contamination or exposure to radiation, assist with decontamination, register, and prioritize for further follow up.
- Primary objective is to identify people who are in immediate danger.
- It is a local/state effort; similar to PODs.

www.bt.cdc.gov/radiation/pdf/population-monitoring-guide.pdf

Community Reception Centers (CRC)

- The place to conduct "population monitoring"
- Primary services include
  - external contamination screening, external decontamination, prioritizing people for further care
- Benefits include
  - providing needed services to affected and concerned people, reducing burden on hospitals, managing scarce medical resources, supporting public shelters
- Staffing
  - Health physics (radiation safety), nursing/medical, and general staff

Thank You!