Medical Response to a Radiological/Nuclear Event

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Official Learning Objectives

• Describe the radiological and nuclear mass casualty events of concern
• Distinguish exposure from contamination
• Identify isotopes of concern and countermeasures
• Understand potential role for physicists in mass casualty responses
• Understand “zones” of response
• Identify where you can volunteer
In a large scale mass casualty radiological or nuclear disaster, there will be a major shortfall of experienced professionals with radiation expertise!

So…. 
Uncle Sam needs you

And so does your state, local, regional, hospital response team!!
What healthcare providers think about rad/nuc events

• One more new, unwelcome task
• Not likely to happen
• Response is futile
• Response is the job of the feds
• Radiation Medicine is too complicated for me to understand
What healthcare providers think about rad/nuc events

• It will be unsafe for me to be a responder
• I need to protect my family
• Too many more important things to learn, practice, certify
• If I learn it now, I will forget it soon
Unofficial Learning Objectives

• Keep you awake
• Make you care about this topic
• Encourage you to volunteer
  • Pick a role to “play”
  • Pick a team to “play for”
• Introduce REMM web portal  
  http://remm.nlm.gov
This can help you collaborate with physicians.

Why I was invited (probably)

- Managing Editor of REMM, Web portal sponsored by HHS/ASPR
- Senior Medical Advisor to the DHHS Assistant Secretary for Preparedness and Response/CBRNE Group
- Radiation Oncologist, National Cancer Institute
• Provide guidance for health care providers, *primarily physicians*, about clinical diagnosis and treatment during mass casualty radiological and nuclear events.

• Provide just-in-time, evidence-based, usable information with sufficient background and context to make complex issues understandable to those *without* formal radiation medicine expertise.

• Provide web-based information that is also downloadable in advance, so that it would be available during an event if the internet is not accessible.
• What kinds of events?
• How are they recognized?
• What is exposure? What is contamination?
  -- Algorithms for diagnosis and treatment
  -- Calculator to estimate dose from exposure
• Up-to-date, peer reviewed evidence for clinical recommendations with PubMed links
• Introduction to Emergency Radiation Medicine
Content

• Isotopes of concern and countermeasures
• Creating/equipping medical response teams
• Links to key guidance documents from government and professional societies
• Bibliography, dictionary
• Much more..
• Entire site downloadable: computer, USB drive, mobile device(s)
• Mobile device versions
• Simple navigation
• Plain language
• Searchable information
• Videos, graphics to illustrate complex concepts
• PubMed hyperlinks to peer-reviewed articles
REMM addresses basic questions from healthcare providers

• What is this event?
• What is the difference between exposure and contamination and?
• How do I measure/estimate dose?
• What are clinical best practices for dx and rx?
• How do I/my family stay safe?
• How do we keep the hospital safe and “uncontaminated”?
Basic answers for healthcare providers
Types of mass casualty radiation disasters

- **Nuclear explosion scenarios**
  - Nuclear weapons
  - Improvised nuclear devices (INDs)

- **Radiological scenarios associated with**
  - Radiological dispersal devices (RDDs)
    - Explosive radiological dispersal devices (RDDs)
    - Non-explosive RDDs
  - Radiological exposure devices (REDs)
  - Nuclear reactors
  - Transportation of radioactive materials
  - Industrial/medical facility radioactive materials

http://remm.nlm.gov/typesofevents.htm
Nuclear vs. Radiological Event (1)

- **Nuclear explosions**
  - Involve fission (splitting) of uranium or plutonium nuclei
  - Represents an exothermic reaction with a rapidly expanding fireball of hot gas or plasma
  - Produces a destructive shock wave
  - Produces radiation exposure and/or contamination

- **Radiological events**
  - Does not involve nuclear fission or a nuclear explosion
  - Radiation exposure and/or radioactive contamination

http://remm.nlm.gov/typesofevents.htm
Nuclear vs. Radiological Event (2)

- **Nuclear explosions**
  - Primary effect
    - Blast effects
    - Thermal effects
    - Prompt radiation
  - Secondary effects include
    - Electromagnetic pulse (EMP)
    - Delayed radiation (radioactive fallout / groundshine)
  - Produce massive destruction, injury, and loss of life.

- **Radiological events**
  - Victim and environmental effects vary by event type and size
  - Usually much smaller event, with many fewer serious casualties
  - Produce exposure and contamination on a much smaller scale
  - Weapon of mass disruption, not destruction
  - Response and clean up can be expensive

http://remm.nlm.gov/typesofevents.htm
How are events discovered

How do you know a radiation event has occurred?

**Obvious in Real Time**
- Information from local, State, Federal authorities
- News report
- Routine, real time radiation monitoring of
  - Industrial radiation sources
  - Planned transport of radiation sources
  - Medical facility radiation sources
- Personal observation

**Examples**
- Nuclear explosion
- Transportation accident
- Medical facility accident
- Nuclear reactor accident or sabotage
- Industrial radiation source accident

**Not Obvious in Real Time**
- Evaluating an explosive event, HAZMAT team tests for and finds radiation.
- Monitoring of water, soil, food, air reveals unexpected radiation.
- Recognizing over time a cluster of victims with radiation-linked clinical signs and symptoms
- Locating a radiation source outside of expected places, e.g., subway, sports field

**Examples**
- Radiological Dispersal Device
  - Explosive incident subsequently found to have radiation
  - Non-explosive incident: radiation dispersion into food, water, soil, air
  - Hidden radiological source: Radiological Exposure Device
- Malicious or unintentional industrial, nuclear reactor, medical facility, or transportation event discovered after the fact

http://remm.nlm.gov/newtype.htm
Radiological Dispersal Device: explosive “Dirty bomb”

http://remm.nlm.gov/rdd.htm#dirtybomb

Source: Armed Forces Radiobiological Research Institute
Radiological Dispersal Device: non-explosive dispersal via air, water, food

http://remm.nlm.gov/rdd.htm#otherdispersalmethods

Source: Armed Forces Radiobiology Research Institute's Medical Effects of Ionizing Radiation Course.
Original Source: U.S. Department of Energy, National Archive
Radiological Exposure Device (RED): example under seat in train

Ci = Curie; R = Roentgen; $\Gamma$ constant = 4.69 R-cm²/mCi-hr

http://remm.nlm.gov/red.htm#reds

Source: Armed Forces Radiobiology Research Institute's Medical Effects of Ionizing Radiation Course.
Original Source: U.S. Department of Energy, National Archive
What is the difference between radiation exposure and contamination?

http://remm.nlm.gov/newptinteract.htm#skip
What is radiation exposure?

http://remm.nlm.gov/exposureimage_top1.htm
What is external contamination?

http://remm.nlm.gov/contamimage_top1.htm
What is internal contamination?

http://remm.nlm.gov/contamimage_top3.htm
What is radiation incorporation?

How do I stay safe?

- Distance
- Time of Exposure
- Shielding
How do I clinically estimate dose from exposure?

http://remm.nlm.gov/ars_wbd.htm
The official stuff:
what you need to know
about what the
government plans to do
How do we know what to do?

- President
  - Homeland Security Presidential Directives
- Department of Homeland Security
  - National Preparedness Guidelines
  - National Response Framework
  - National Planning Scenarios
  - Developing and maintaining state and local government emergency plans
How do we know what to do?

- Department of Homeland Security
  - National Response Framework
    - Emergency Support Function #8 — Public Health and Medical Services
    - Nuclear/Radiologic Incident Annex
    - Catastrophic Incident Annex
    - Worker Safety and Health Support Annex
  - National Incident Management System (NIMS) (includes ICS)
    - Hospital Incident Command System (HICS)
  - Draft guidance for planning nuclear power plant responses
- Homeland Security Council: interagency
  - Planning guidance for response to a nuclear detonation
Hospital Incident Command System

National Planning Scenarios

- **Scenario 1: Nuclear Detonation** – 10 Kiloton Improvised Nuclear Device
- Scenario 2: Biological Attack – Aerosol Anthrax
- Scenario 3: Biological Disease Outbreak – Pandemic Influenza
- Scenario 4: Biological Attack – Plague
- Scenario 5: Chemical Attack – Blister Agent
- Scenario 6: Chemical Attack – Toxic Industrial Chemicals
- Scenario 7: Chemical Attack – Nerve Agent

National Planning Scenarios

- Scenario 8: Chemical Attack – Chlorine Tank Explosion
- Scenario 9: Natural Disaster – Major Earthquake
- Scenario 10: Natural Disaster – Major Hurricane
- **Scenario 11: Radiological Attack – Multiple Explosive Radiological Dispersal Devices:** Cesium-137
- Scenario 12: Explosives Attack – Bombing Using Improvised Explosive Devices
- Scenario 13: Biological Attack – Food Contamination
- Scenario 14: Biological Attack – Foreign Animal Disease (Foot and Mouth Disease)
- Scenario 15: Cyber Attacks
What will radiation professionals do?
Public Health Physics

Courtesy: Armin Ansari, Ph.D, CHP/CDC
Radiation Professionals in a large scale radiation emergency

- Monitor environment, workplace
- Monitor population: near and far
- Support operations at
  - Hospitals... even those hundreds of miles away
  - Public and special needs shelters
  - Emergency operations centers
  - Community reception centers
- “Translate” event information to medical colleagues and event managers
- Guide creation of public messaging
Radiation Professionals in a large scale radiation emergency

- Assist event managers and security personnel in establishing safe response zones
- Support the implementation of appropriate protective actions
- Supervise or perform radiation surveys assessing contamination of victims and responders: standard surveys, abbreviated surveys in mass casualty
- Assist with estimates of dose received by both victims and responders and interpretation of health effects
Radiation Professionals in a large scale radiation emergency

• Participate in the collection and transport of radiation bioassays for contamination
• Supervise decontamination of victims and responders
• Assist with decorporation strategies for internal contamination
• Assist with short- and long-term tracking of both victims and responders
You already know a lot about

- Radiation physics and medicine
- Radiation safety procedures in your [area]
- Radiation survey equipment
  - Selection, calibration, maintenance, use
- Selection and use of appropriate dosimeters
- Protective actions and guidelines
- Controlled area access
- Radiation safety training
You may need to learn

- What scenarios are of greatest concern
- What the key clinical decision points are and how radiation measurements help
- Where you “fit” in a mass casualty event (ICS, HICS)
You may need to learn

- How normal radiation surveys may be modified in a mass casualty setting
  - Speed and technique of surveys
  - Modified NM cameras as scanners, must be planned and practiced in advance
- How to Dx and Rx
  - Significant internal contamination levels
    ALI vs. CDG (NCRP)
  - Significant whole body exposure (ARS)
- How to work with scarce resources: stuff, staff, space
Where you can learn more

- NCRP Population monitoring guidance, to be released soon
Who is responsible? Locals

- Decontamination is **accomplished locally and is the responsibility of State, tribal, and local governments.**
- DHHS coordinates **Federal support** for external monitoring of people and for population decontamination.
- DHHS **assists and supports** State, tribal, and local governments in performing monitoring for internal contamination and administering available pharmaceuticals for internal decontamination, as deemed necessary by State health officials.
- DHHS **assists** local and State health departments in establishing a registry of potentially exposed individuals, performing dose reconstruction, and conducting long-term monitoring of this population for potential long-term health effects.

Per [National Response Framework](#)
Integrated mass casualty response: local to state to national

The initial response is local
Feds provide assistance to locals
Response zones: distances vary

- Improvised Nuclear Device
- RDD: explosive, non-explosive
- Nuclear power plant
- RED
- Other
Response zones: complicated

- How is map generated?
  -- modeling vs. real-time measured data
- What is being mapped?
  -- overpressure, heat, radiation, fallout
- Radiation measurements vary
  -- units measured: R, rad, rem, Sv, others
  -- rate or cumulative at certain time and location
  -- time: minute(s), hour(s), day(s), lifetime
- Who is map for?
  -- public vs. response staff
- What is map being used for?
  -- early, intermediate, late response activity
Response zones: complicated

- Linked to "Protective Action & Guides" (PAs and PAGS):
  - different responder duties allowed @5, 10, 25 rem acute exposure
  - different recommendations to public: evacuate vs. shelter

- Recommendations vary:
  - professional societies: NCRP, CRCPD, ICRP
  - government entities: Federal (DHS, DOD, HHS, EPA), State, local
  - responder groups and exact location: fire, police, EMS
  - what is your role? what is your task?

- Reflect the nature/size of the incident:
  - RDD, RED, IND

- Zones change over time:
  - wind, decay, iterative data revisions

- Multiple isotopes complicate calculations

- Federal source of mapping information:
  - feds use NARAC, IMAAC;
  - other competing data sets may complicate operations and plans
Integrating the Medical Response and the Radiation Levels
# Isotopes of interest and countermeasures

<table>
<thead>
<tr>
<th>Isotope</th>
<th>Half-life</th>
<th>Energy (meV)</th>
<th>Countermeasure</th>
</tr>
</thead>
</table>
| $^{60}$Co | 5.27 y | γ (1.17)  
γ (1.33) | No FDA approved |
| $^{90}$Sr/$^{90}$Y | 28.8 y/64 h | β (0.546)  
β (2.28) | No FDA approved |
| $^{131}$I | 8.02 d | β (0.606)  
γ (0.364) | Potassium Iodide |
| $^{137}$Cs | 30.2 y | γ (0.662) | Prussian Blue |
| $^{192}$Ir | 73.8 d | γ (0.317) | No FDA approved |
| $^{226}$Ra | 1,600 y | α (4.78)  
γ (0.186) | No FDA approved |
| $^{235}$U | 7.04 x 10^8 y | α (4.40) | No FDA approved |
| $^{238}$U | 4.47 x 10^9 y | α (4.20,4.15) | No FDA approved |
| $^{238}$Pu | 87.7 y | α (5.46,5.50) | Ca-DTPA IV  
then Zn-DTPA IV  
or nebulizers |
| $^{239}$Pu | 24,100 y | α (5.16, 5.14) | DTPA |
| $^{241}$Am | 432 y | α (5.5)  
γ (0.060) | DTPA |
Understand internal contamination

- How to screen for it after external decontamination*
- How to quantify internal contamination*
- What threshold suggests need for treatment*
- How to procure decorporation agents in your state
- What is cost/benefit ratio of decorporation treatment
- How to evaluate effectiveness of treatment
- How to manage the hospitalized patient: rx and safety
- How to manage contaminated remains


*NCRP Population guidance, to be released soon
Clinical threshold for decorporation

- **Exceeding the “Allowable Limits of Intake” ALI**
  chronic intake by rad worker (occupational exposure)
- Exceeding level in “Clinical Decision Guide (CDG)”
  - Draft proposal by NCRP for acute episode
  - Isotope specific
  - Translation of detected activity into absorbed dose related to deterministic effects
- **New guidance from HPA: inhaled isotopes**
- **Older guidance from ICRP**
IND and internal contamination

- The four significant nuclides that account for nearly three-fourths of the reconstructed whole-body internal dose to people who lived within a few hundred kilometers of the Nevada Test Site have been identified as Sr-89, Sr-90, I-131, and Cs-137.

- Inhalation is a minor consideration relative to ingestion for uptake of fallout products (Peterson and Shapiro, 1992; Levanon and Pernick, 1988). The majority of internal exposures to individuals in the Peterson and Shapiro (1992) study occurred from eating contaminated food.

- With respect to determining the relevance of prophylactic administration of medical countermeasures, particularly potassium iodide (KI), only the contribution to dose of radionuclides inhaled or ingested needs be considered.

- The FDA has concluded that once the plume has passed, prevention of thyroid uptake of ingested iodine-131, the longest lived of the radioactive isotopes of iodine with a half-life of about 8 days, is best accomplished by food control measures and not by administration of KI.

Personal communication: Tammy Taylor, Ph.D., P.E., White House HSC, 6/2009
Planning for radiation mass contamination events

- Protect/secure the ED, rest of hospital, equipment
- Protect staff, patients, families
- Plan exterior locations for triage, decon, minor care
- Plan for admission of contaminated patients
- Prevent/deal with contamination within hospital
- Acquire, perform, interpret radiation bioassays
- Manage radioactive waste, contaminated remains

See soon to be published NCRP Population Monitoring document
Uncle Sam needs you

And so does your state, local, regional, hospital response team!!
Radiation Professionals who could volunteer?

Have you and your colleagues volunteered yet?

Courtesy: Armin Ansari
So where can you volunteer?

Source: RADM Ann Knebel, D.Sc., USPHS, HHS/ASPR/OPEO
Decoding the volunteer puzzle

- **Metropolitan Medical Response System (MMRS)**
- **Medical Reserve Corps (MRC)**
- American Red Cross (ARC)
- US Department of HHS
  - National Disaster Medical System (NDMS)
  - US Public Health Service (PHS)
    - Active duty officers (OFRD)
  - Inactive reserve officers (ORA)
- Departments of Defense: detection assets but few medical providers
- Veterans Affairs: some medical assets, hospitals
- State, local, tribal response: staff, stuff, space
- Your Hospital assets: staff, stuff, space
Medical Reserve Corps Models

- No “typical” MRC
- MRC units are not first responders
  - Provide an organizational structure for using/managing and members to supplement the first responders
  - Pre-identify and pre-credential members (licensed, certified)
  - Train/prepare members
- Units vary by:
  - Types/#s of volunteers
  - Sponsor organizations
  - Partner organizations
  - Mission/focus

http://www.medicalreservecorps.gov/
Medical Reserve Corps Units

Total MRC Units: 653

(Note > 800)
MRC volunteers: numbers and professions

> 180,000 MRC volunteers in > 800 units

Number of MRC Members by Categories
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Questions?

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