RADIOLOGICAL EMERGENCY MEDICAL PREPAREDNESS & MANAGEMENT: KEY ELEMENTS FOR SUCCESS

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Medical Response Subcommittee

Health Physicists play a major role in medical radiological emergency response. Preparedness will ensure that treatment of life threatening injuries or medical conditions takes priority over surveys for and removal of radioactive contamination. Hospital emergency planning, training, and drills will instill confidence in the staff to manage these emergencies.

The Medical Response Subcommittee members are:

Jerrold T. Bushberg, PhD, DABMP, Chair (University of California Davis Health System)
Marcia Hartman, MS (University of California Davis Health System)
Linda Kroger, MS (University of California Davis Health System)
John J. Lanza, MD, PhD, MPH, FAAP (Florida Department of Health)
Edwin M. Leidholdt, Jr., PhD, ABR (Univ of California Davis and Dept of Veterans Affairs National Health Physics Program)
Mark A. Melanson, PhD, CHP (US Army Radiological Advisory Medical Team)
Kenneth L. Miller, MS, CHP, CMHP (Penn State Hershey Medical Center)

Individual members of the Society have suggested these websites and reports as useful references for additional information on the subject of medical response to a radiological emergency:

Visit http://hps.org/hsc/responsemed.html
Scope of Training For Medical Responders

- Characteristics of ionizing radiation and radioactive materials
- Differentiation between radiation exposure and radioactive material contamination
- Staff radiation protection procedures and practices
- Facility preparation
Visualizing Radiation

Source: http://faraday.physics.uiowa.edu/modern/7D30.60b.htm
Scope of Training For Medical Responders (Cont.)

- Patient assessment and management of radioactive material contamination and radiation injuries
- Health effects of acute and chronic radiation exposure
- Psychosocial considerations
- Facility recovery
- Resources
Causes of Radiation Exposure/Contamination

- **Accidents**
  - Nuclear reactor
  - Medical radiation therapy
  - Industrial irradiator
  - Lost/stolen medical or industrial radioactive sources
  - Transportation

- **Terrorist Event**
  - Radiological dispersal device (dirty bomb)
  - Radiological exposure device
  - Low yield nuclear weapon
Instructor Notes For Every Slide (example)

Causes of Radiation Exposure and Contamination

**Accidents** - There are several settings or scenarios in which radiation accidents may occur: nuclear reactor accidents; medical radiation therapy accidents or errors in treatment dose; accidental overexposures from industrial irradiators; lost, stolen or misused medical or industrial radioactive sources; and accidents during the transportation of radioactive material.

**Terrorist Use of Nuclear Materials** - The use of radioactive materials in an RDD or a nuclear weapon by a terrorist is a remote but plausible threat. The medical consequences depend on the type of device used in a terrorist event. An attack on or sabotage of a nuclear facility, such as an irradiation facility or a nuclear power plant, could result in the release of very large amounts of radioactive material.

**Radiological Dispersal Device (RDD)** - A RDD disperses radioactive material for the purpose of terrorism. A RDD that uses a conventional explosive (e.g., TNT or a plastic explosive) to disperse the radioactive material is called a “dirty bomb”. A dirty bomb is NOT an atomic bomb. The initial explosion may kill or injure those closest to the bomb, while the radioactive material remains to expose and contaminate survivors and emergency responders.

**Low Yield Nuclear Weapon** - A low yield nuclear weapon or partial failure of a high yield weapon could cause a low yield nuclear detonation. For example, if one considers the consequences of a 0.1 kiloton yield nuclear detonation (less than 1/100 the size of the weapon used on Hiroshima), then the following would occur within one minute surrounding ground zero. The effects listed below do not take into account that multiple injuries caused by the interaction of the various types of injury will increase the probability of fatality. (NCRP Report No. 138)

- The range for 50% mortality from trauma from the blast is approximately 150 yards.
- The range for 50% mortality from thermal burns is approximately 220 yards.
- The range for 400 rad from gamma and neutron radiation would be approximately 1/3 mile.
- The range for 400 rad in the first hour from radioactive fallout would be almost 2 miles in the downwind direction.
- As the size of the weapon increases, the effects encompass a greater distance. This will result in the release of widespread contamination and substantial air blast and heat.
**Time**

Minimize time spent near radiation sources

**Distance**

Maintain maximal practical distance from radiation source

<table>
<thead>
<tr>
<th>Distance</th>
<th>Rate</th>
<th>Stay time</th>
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<tr>
<td>1 ft</td>
<td>1.0 R/hr</td>
<td>25 hr</td>
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<tr>
<td>2 ft</td>
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<tr>
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<td>~1 month</td>
</tr>
<tr>
<td>8 ft</td>
<td>64 x’s lower</td>
<td>~2 months</td>
</tr>
</tbody>
</table>

**Shielding**

Place radioactive sources in a lead container

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**Radiation Protection**

**Reducing Radiation Exposure**
Protecting Staff from Contamination

- Universal precautions
- Survey hands and clothing with radiation meter
- Replace gloves or clothing that is contaminated
- Minimize the spread of contamination

Key Points

- Contamination is easy to detect and most of it can be removed
- It is very unlikely that ED staff will receive a significant radiation doses from treating contaminated patients
Standards For The Transport & Care of Contaminated Patients

International, national and state standards of responding to a radiological incident provide for the *immediate treatment and transport* of critical patients, emphasizing that *medical response has priority over decontamination*.
Life Threatening? Yes → Treat without regard for contamination

Transport to Hospital
The Fly In The Ointment

- Current understanding of responding and treating victims of a radiation incident falls within the response to generalized hazardous materials.

- Hazardous material policy in the most regions requires all contaminated victims of a hazardous materials incident to be decontaminated prior to medical treatment or transport.

- Example: Sacramento County Emergency Medical Service policy number 8029.05 states medical transportation units will only accept decontaminated patients from a HAZMAT team.
The Fly In The Ointment

• There are no provisions in place to accommodate transportation of critically injured, radiation contaminated patients.

• Unlike decontamination procedures required for generalized hazardous materials, the critically injured patients at a radiological event do not pose a significant treat to healthcare providers and must be triaged and treated for life threatening injuries prior to initiating time-consuming decontamination procedures.
Consortium of Technical Responders (CTR)  
Sacramento Area Chapter

CTR Objectives (partial list)

✓ Provide **one source, one voice** for Command Staff, City and County Government, and all others, for guidance and information on CBRN response capabilities, roles, and missions.
✓ Define and support the role of the Technical Responder
✓ Provide the forum for continuing education, information exchange and guidance for appropriate training
✓ Continual review of technologies, procedures and applications to assure best practice.
✓ Peer review of protocols in order to develop understanding and continuity.
Consortium of Technical Responders (CTR) Sacramento Area Chapter

Structure

46 representatives from:

✓ City & county: fire, law enforcement & health department
✓ State agencies (e.g., OES, CHP)
✓ Federal agencies (e.g., FBI, Postal Svc, USCG, Nat’l Guard -CST)
✓ UC Davis Subject Matter Experts in Chem, Bio, & Rad

Monthly meetings & Quarterly training
Preserve Critical Assets

• In a mass causality event it is vital that critical assets are not taken out of service due to low levels of radioactive contamination.
  
  – Critical assets such as EMS patient transport vehicles, life flight, trauma rooms, etc. should not be taken out of service if there is a critical need to use them.
  
  – The risks to the patients and staff are minimal.
  
  – Restricting these resources may unnecessarily cost lives.
  
  – Staff & patient decontamination is relatively easy to detect and remove
Psychological Casualties

• Terrorist acts involving toxic agents (especially radiation) are perceived as very threatening.

• Mass casualty incidents caused by nuclear terrorism will create large numbers of worried people who may not be injured or contaminated.

• Provide psychological support to such people.
Only Seriously Injured People Should be Directed to the Emergency Department (ED)

- Contaminated with minor injuries, Contamination only, Uninjured People, and Psychological Casualties
- Measures must be taken to prevent these people from overwhelming the ED.
- A triage site should be established outside the ED to intercept such people and divert them to appropriate locations (e.g. decon center).
  - Triage site should be staffed with medical staff and security personnel
  - Precautions should be taken so that they cannot avoid the triage center and reach the ED
  - Decon Center should be staffed with radiological monitoring & decon staff, medical staff to treat minor injuries, psychological support and security personnel
The Cs-137 teletherapy source was inadvertently ruptured during an unauthorized salvage operation of an abandoned radiation therapy machine. The Cs-137 was in the form of a very dispersible cesium chloride salt and had, at the time of the accident, activity of ~1,400 Ci. Exposure was approx 5,000 R/hr at 1 foot. The source capsule was ruptured and initiated the dissemination of cesium.

85 homes had significant level of contamination, 41 evacuated, demolished & ~3,000 m³ radioactive waste, economic impact ~$70 million & 10 years to recover, social stigmata. Current estimates for US port or major urban center >$35 billion!
### Goiânia: Lesson for RDD Preparedness

<table>
<thead>
<tr>
<th>Category</th>
<th>Number</th>
<th>% of Pop’n</th>
</tr>
</thead>
<tbody>
<tr>
<td>Total Population</td>
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<td>100</td>
</tr>
<tr>
<td>Persons Monitored</td>
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<tr>
<td>Persons with External and Internal Doses</td>
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<td>0.025</td>
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<tr>
<td>Persons Admitted to Hospital</td>
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<td>0.005</td>
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<tr>
<td>Persons Needing Intensive Medical Care</td>
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<td>0.002</td>
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<tr>
<td>Deaths</td>
<td>4</td>
<td>0.0004</td>
</tr>
<tr>
<td>Forearm Amputated</td>
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<td>0.0001</td>
</tr>
</tbody>
</table>

[Photo credits: IAEA](http://www-pub.iaea.org/MTCD/publications/PDF/Pub815_web.pdf)
Why We Fear Radiation
The “R” Word
Radiation and Nuclear Weapons
Radiation and Nuclear Power Accidents
Radiation and Monsters
Radiation and Monsters
Radiation and the Tabloids

Poisoned by radioactivity... Moms give birth to babies that look like chimps

WEATHER TOWER RADIATION GAVE ME CANCER!

SECRET$ TO WINNING A PAY RAISE

SECRET for a raise this year? There's one that you can use. It's not pay raises per se, but raises in the wrong places!
When Pigs Fly....
Detecting and Measuring Radiation

• **Instruments**
  – Locate contamination - GM Survey Meter (Geiger counter)
  – Measure exposure rate - Ion Chamber

• **Personal Dosimeters - measure doses to staff**
  – Radiation Badge - Film/TLD/OSL
  – Self reading dosimeter (analog & digital)
Hospital Preparation

- Assemble radiation emergency supplies
- Ensure adequate number of survey meters
- Check operation of survey meters
- If available, request equipment for identification of radionuclides
Patient Management - Priorities

Triage

- *Medical triage is the highest priority*
- Radiation exposure and contamination are secondary considerations
- Degree of decontamination dictated by number of and capacity to treat other injured patients
- Cease decontamination of skin and wounds
  - *When the area is less than twice background, or*
  - *When there is no significant reduction between decon efforts*
  - *Before intact skin becomes abraded.*
- Internal contamination typically not life threatening—most treatments only reduce dose 2-3x’s—no magic bullet
- Do not delay surgery or other necessary medical procedures or exams…residual contamination can be controlled
Acute Radiation Syndrome (Cont.)
For Doses > 100 rem

• **Prodromal stage**
  – nausea, vomiting, diarrhea and fatigue
  – higher doses produce more rapid onset and greater severity

• **Latent period (Interval)**
  – patient appears to recover
  – decreases with increasing dose

• **Manifest Illness Stage**
  – Hematopoietic
  – Gastrointestinal
  – CNS
Localized Radiation Effects - Organ System
Threshold Effects

- **Skin - No visible injuries < 100 rem**
  - Main erythema, epilation >500 rem
  - Moist desquamation >1,800 rem
  - Ulceration/Necrosis >2,400 rem

- **Cataracts**
  - Acute exposure >200 rem
  - Chronic exposure >600 rem

- **Permanent Sterility**
  - Female >250 rem
  - Male >350 rem
Perspective on Health Risks from Radiation

- Radiation is a weak carcinogen at low doses
- No unique effects (type, latency, pathology)
- Natural incidence of cancer ~ 40%; mortality ~ 25%
- A dose of 5 rem increases the risk of fatal cancer from ~ 25 to 25.2%
- Approximately 1/3 of cancer deaths could be prevented by optimization of diet and exercise
- Fetal Irradiation--No significant risk of adverse developmental effects below 10 rem
Radiation Risk – Low Dose

In our society, about 25% of the population will die of cancer. In 10,000 people, this means that 2,500 will die from cancer.

If 10,000 people were to be given 1 rem of radiation, statistics suggest that there may be 5 additional cancer deaths.

This suggests that the risk of excess cancer deaths is increased by a factor of about 0.0005 per rem.
Facility Recovery

- Remove waste from the Emergency Department and triage area
- Survey facility for contamination
- Decontaminate as necessary
  - Normal cleaning routines (mop, strip waxed floors) typically very effective
  - Periodically reassess contamination levels
  - Replace furniture, floor tiles, etc. that cannot be adequately decontaminated
- Decontamination Goal: Less than twice normal background…higher levels may be acceptable
Key Points

• **Medical stabilization is the highest priority—*Do not delay transport or treatment for decontamination efforts*—**

• Train/drill to ensure competence and confidence

• Pre-plan to ensure adequate supplies and survey instruments are available

• Universal precautions and decontaminating patients minimizes exposure and contamination risk

• Have Decon & Minor Injury Treatment Centers to preserve the ED for critical patient care

• Preserve critical assets even if they are contaminated

• The first 24 hours are the worst; then you will likely have many additional resources
Resources

• Radiation Emergency Assistance Center/ Training Site (REAC/TS) (865) 576-1005
  www.orau.gov/reacts

• Medical Radiobiology Advisory Team (MRAT) Armed Forces Radiobiology Research
  Institute (AFRRI) (301) 295-0530 www.afrrri.usuhs.mil
  – Medical Management of Radiological Casualties Handbook, 2003; and Terrorism with Ionizing
    Radiation Pocket Guide

• Websites:
  – http://hps.org/hsc/documents/emergency.ppt - Emergency Department Management of
    Radiation Casualties,” Hospital staff training prepared as a public service by the Health
    Physics Society.
  – Radiation Event Medical Management (REMM) web portal Department of Health and
    Human Services: http://remm.nlm.gov
  – www.bt.cdc.gov/radiation - Response to Radiation Emergencies by the Center for
    Disease Control
  – www.acr.org - “Disaster Preparedness for Radiology Professionals” by American
    College of Radiology
  – www.va.gov/emshg - “Medical Treatment of Radiological Casualties”
Resources

• Books:
  – Medical Effects of Ionizing Radiation; Mettler and Upton, 1995.
  – National Council on Radiation Protection Reports Nos. 65 (revision due out 2007) and 138 and Commentary No. 19 - Key Elements of Preparing Emergency Responders for Nuclear and Radiological Terrorism (2005)

• Articles:
Visit http://remm.nlm.gov/
WHAT KIND OF EMERGENCY?

- Radiological Dispersal Devices:
  Dirty Bomb, Other Dispersal Methods, Hidden Sealed Source
- Nuclear Explosions: Weapons, Improvised Nuclear Devices
- Nuclear Reactor Accidents
- Transportation Accidents
- Discovering an Event

PATIENT MANAGEMENT

- Choose Appropriate Algorithm:
- Evaluate for Contamination/Exposure
- Contamination
- Exposure (Acute Radiation Syndrome)
- Exposure + Contamination

MANAGEMENT MODIFIERS

- Radiation + Trauma
- Burn Triage and Treatment
- Mass Casualty
- Psychological Issues
- Specific Populations

INITIAL EVENT ACTIVITIES

- Onsite Activities
- Triage Guidelines
- Hospital Activities
OTHER AUDIENCES
- First Responders in the Field
- Mental Health Professionals
- Hospitals
- Public Information Officers
- Radiation Safety and Protection
- Preplanning
- Practices and Drills

ABOUT THIS SITE
- What Are the Goals of This Site?
- Who Produced This Site?
- Disclaimers
- List of Consultants
- Join the REMM ListServ
- Contact us: Provide Site Feedback
- Download REMM to Your Computer
- System Requirements (e.g., Allow Pop-ups)

TOOLS & GUIDELINES
- Dose Estimator for Exposure
- Template for Hospital Orders
- Use of Blood Products
- Follow-up Instructions
- Manage Long-Term Monitoring
- Management of the Deceased
- Develop a Hospital Medical Response Team
- Develop a State Response Plan
- Equip an Emergency Room for Decontamination

REFERENCE/DATA CENTER
- Dictionary
- Animations, Illustrations, Photos
- Emergency Contacts
- Abbreviations
- Understanding Radiation
- Sources of Radiological/Nuclear Information
FEATURES

- Polonium-210 Information: Properties, Treatment, and Fact Sheets
- NIH Radiation Countermeasures Strategic Plan, 6/2005 (NIH/NIAID)
- Medical Countermeasures Program Against Radiological and Nuclear Threats (NIH/NIAID)

QUICK LINKS

- New Users: Where Do I Start?
- Isotopes of Interest
- Countermeasures
- Dose Estimator for Exposure
- Manage ARS Subsyndromes
- Hematopoietic Subsyndrome
- Time/Dose Effects in ARS
- Strategic National Stockpile
- Animations, Illustrations, Photos
- Dictionary
- Emergency Contacts
- Download This Site
- Print Algorithms & Tables

OTHER WEB RESOURCES

- AFRRI
- AHRQ
- CDC
- DHS
- DOE
- EPA
- FDA
- HHS
- IAEA
- NCRP
- NRC
- OSHA
- REAC/TS
- WHO
Closing Thought

It is likely that terrorist use of an RDD is more a matter of *when* rather than *if*. However...

one of the major considerations that will determine if RDDs continue to be used as a “weapon of choice” for terrorism…… will be how well (or poorly) we respond to the first incident.

Thus it is essential to develop effective Public Communication Strategies—Federal, State & Local Emergency Preparedness Programs — Response Capabilities
QUESTIONS ?