The Role of the Medical Physicist in Preparing for Radiation Disasters

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Emergency Preparedness

• Partner with Emergency Dept (ED)
• Participate Emergency Preparedness Committee
• Hospital Rad Emergency Response Plan
• Pre-plan for adequate supplies and survey instruments
• Training and drills - annually
• 1st 24 hours – You are on Your Own! (YOYO)

Emergency Preparedness

• For trauma patients – Golden hour
• Medical stabilization is the highest priority
• Universal precautions
• Capability to identify all hazards present
• Emergency Department staff dose limits
  – Pregnant workers, volunteers (risks)
• Contamination limits
• Decon inside or outside ED?

Causes of Radiation Exposure/Contamination

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

Causes of Radiation Exposure/Contamination

• Terrorist Event
  – Radiological dispersal device (dirty bomb)
  – Radiological dispersal device
    • Food or water
    • Contaminate ground
  – Radiological exposure device
  – Attack on nuclear facility
  – Low yield nuclear weapon

Examples of Radioactive Materials

<table>
<thead>
<tr>
<th>Radionuclide</th>
<th>Half-Life</th>
<th>Emit</th>
<th>Use</th>
</tr>
</thead>
<tbody>
<tr>
<td>Cobalt-60</td>
<td>5 yr</td>
<td>β, γ</td>
<td>Cancer Therapy</td>
</tr>
<tr>
<td>Strontium-90</td>
<td>29 yr</td>
<td>β</td>
<td>Therapy Device, RTG</td>
</tr>
<tr>
<td>Iodine-131</td>
<td>8 days</td>
<td>β, γ</td>
<td>Nuclear Medicine Therapy</td>
</tr>
<tr>
<td>Cesium-137</td>
<td>30 yr</td>
<td>β, γ</td>
<td>Food Irradiator</td>
</tr>
<tr>
<td>Iridium-192</td>
<td>74 days</td>
<td>β, γ</td>
<td>Industrial Radiography</td>
</tr>
<tr>
<td>Plutonium-239</td>
<td>24,000 yr</td>
<td>α, γ</td>
<td>Nuclear Weapon</td>
</tr>
<tr>
<td>Americium-241</td>
<td>432 yr</td>
<td>α, γ</td>
<td>Well Logging Gauges</td>
</tr>
</tbody>
</table>
Types of Ionizing Radiation

- **Alpha Particles**
  - Stopped by a sheet of paper

- **Beta Particles**
  - Stopped by a layer of clothing or less than an inch of a substance (e.g., plastic)

- **Gamma Rays**
  - Stopped by inches to feet of concrete or less than an inch of lead

Use these tips w/survey meter

Types of Radiation Hazards

- **External Exposure** - 
  - whole-body or partial-body (no rad hazard to staff)

- **Contaminated** - 
  - external radioactive material: on the skin
  - internal radioactive material: inhaled, swallowed, absorbed through skin or wounds

Facility Preparation

Activate hospital plan

- Staff support
  - Nuclear Medicine
  - Radiation Oncology
  - Radiation Safety/ Health Physics
  - Researchers
- Radiation survey meters
- Decontamination supplies

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
  - Self reading dosimeter (analog & digital)

Detecting and Measuring Radiation

- **SIRAD** (Self-indicating Instant Radiation Alert Dosimeter)
Contaminated Waste Treatment Area Layout

- Contaminated Waste
- Trauma Room
- Separate Entrance
- Radiation Survey
- ED Staff
- Clean Area
- Contaminated Area
- Buffer Zone
- Clean Gloves, Masks, Gowns, Booties

Protecting Staff from Contamination
- Universal precautions
- Survey hands and clothing with radiation meter
- Replace gloves or clothing that is contaminated
- Keep the work area free 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 large radiation doses from treating contaminated patients

Radiation Protection Reducing Radiation Exposure

Time
- Minimize time near radiation sources

Distance Rate Stay time
1 ft 12.5 R/hr 24 min
2 ft 3.1 R/hr 1.6 hr
5 ft 0.3 R/hr 10 hr
8 ft 0.2 R/hr 25 hr

Shielding
- Place sources in a lead container

Patient Management - Triage

Triage based on:
- Injuries
- Signs and symptoms - nausea, vomiting, fatigue, diarrhea
- History - Where were you when the bomb exploded?
- Contamination survey

Priorities
- Treat & stabilize life-threatening injuries
- Prevent & minimize internal contamination
- Assess external contamination & decon
- Assess & treat internal contamination
- Contain contamination to treatment area
- Minimize external radiation to staff

Contamination Control
- Universal precautions and double glove
- Multiple receptacles for contaminated waste
- Protect floor with covering
- Transport of contaminated patients into ED
  - designate separate entrance,
  - designate one side of corridor, or
  - transfer to clean gurney before entering
**Patient Management - Patient Transfer**

Transport injured, contaminated patient into or from the ED:
- Clean gurney covered with 2 sheets
- Lift patient onto clean gurney
- Wrap sheets over patient
- Roll gurney into ED or out of treatment room

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**Radionuclide Identification**

- Equipment for ID radionuclides and estimated activity
- Dose rate measurement
- Assists with decontamination planning
- Nuclear Medicine gamma counter or thyroid probe

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**Radionuclide Identification**

- DOE Triage System
- National Lab gamma spectroscopy scientists
- Initiate by calling ERO: 202-586-8100
- Send data to: triage.data@hq.doe.gov
  triage.data@llnl.gov

HDR source - 10.7 Ci through lead shielding

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**Contamination Surveys**

- Survey with GM survey meters
- Goal is <5 times background
- Prepare protocol for survey & documentation
- Facial contamination - internal exposure likely

- Probe held ~ 1/2 inch from surface
- Move at a rate of 1 to 2 in. per second
- Follow logical pattern
- Document readings in counts per minute (cpm)

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**Patient Management - Decontamination**

- Change outer gloves frequently to minimize spread of contamination
- Carefully remove and bag patient’s clothing and personal belongings (typically removes 95% of contamination)
- Survey patient and collect samples
- Handle foreign objects with care until surveyed
- Protect non-contaminated wounds with waterproof dressings
- Decontamination priorities:
  - Decontaminate wounds, then intact skin
  - Start with highest levels of contamination

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**Patient Management - Decontamination (Cont.)**

- Contaminated wounds:
  - Irrigate & gently scrub with surgical sponge
  - Extend wound debridement for removal of contamination only in extreme cases and upon expert advice
- Decontaminate intact skin & hair washing with soap & water
- Avoid overly aggressive decontamination
- Remove stubborn contamination on hair by cutting with scissors or electric clippers
- Survey to monitor progress of decontamination
**Patient Management - Decontamination (Cont.)**

- Promote sweating
- Change dressings frequently
- Cease decontamination of skin and wounds
  - When no significant reduction between efforts, and
  - Before abrading skin
- Contaminated thermal burns
  - Gently rinse
  - Dressings remove contamination
- Do not delay surgery or other necessary medical procedures or exams...residual contamination can be controlled

**Special Considerations**

- High radiation dose and trauma interact synergistically to ↑ mortality
- Close wounds pt with doses > 100 rem
- Wound, burn care & surgery within first 48 hours or delay 2 to 3 months (> 100 rem)

<table>
<thead>
<tr>
<th>Emergency Surgery</th>
<th>Hematopoietic Recovery</th>
<th>Surgery Permitted</th>
</tr>
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<tr>
<td>24 - 48 Hours</td>
<td>~3 Months</td>
<td>After adequate hematopoietic recovery</td>
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**Treatment of Internal Contamination**

- Radionuclide-specific
- Administer early ↑ effectiveness
- May need to act on preliminary information
- NCRP Report No. 65, Management of Persons Accidentally Contaminated with Radionuclides

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<thead>
<tr>
<th>Radionuclide</th>
<th>Treatment</th>
<th>Route</th>
</tr>
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<tbody>
<tr>
<td>Ca-137</td>
<td>Prussian blue</td>
<td>Oral</td>
</tr>
<tr>
<td>I-125/131</td>
<td>Potassium iodide</td>
<td>Oral</td>
</tr>
<tr>
<td>Am-241</td>
<td>Ca- and Zn-DTPA</td>
<td>IV infusion, nebulizer</td>
</tr>
<tr>
<td>Pu-238/239</td>
<td>Co-60</td>
<td></td>
</tr>
<tr>
<td>Sr-90</td>
<td>Aluminum phosphate</td>
<td>Oral</td>
</tr>
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</table>

**Acute Radiation Syndrome**

For Doses > 100 rem

- **Prodromal stage**
  - nausea, vomiting, diarrhea and fatigue
  - ↑ doses, more rapid onset & greater severity
- **Latent period (Interval)**
  - patient appears to recover
  - decreases with increasing dose
- **Manifest Illness Stage**
  - Hematopoietic (70 rem)
  - Gastrointestinal (1000 rem)
  - CNS (5000 rem)

**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

**Treatment of Large External Exposures**

- Estimating the severity of radiation injury is difficult.
  - Signs and symptoms (N.V.D.F): Rapid onset & greater severity indicate higher doses. Can be psychosomatic.
  - CBC with absolute lymphocyte count
  - Chromosomal analysis of lymphocytes
- **CytoGenetics Laboratories**
  - AFRRI – <blakely@afri.usush.mil>
  - Health Protection Agency (Formerly NRPB) - <cytogenetics@hpa-rp.org.uk>
Lymphocyte Depletion Curves

Curves correspond roughly to the following whole-body doses:

- Curve 1 - 3.1 Gy
- Curve 2 - 4.4 Gy
- Curve 3 - 5.6 Gy
- Curve 4 - 7.1 Gy

Treatment of Large External Exposures

- Treat symptomatically
- Prevention and management of infection is the primary objective
  - Hematopoietic growth factors, e.g., GM-CSF, G-CSF, Neupogen®
  - Irradiated blood products
  - Antibiotics/reverse isolation
  - Electrolytes

Chronic Health Effects from Radiation

- Radiation is a weak carcinogen at low doses
- No unique effects (type, latency, pathology)
- Natural incidence of cancer ~ 40%; mortality ~ 25%
- Risk of fatal cancer estimated as ~ 4% per 100 rem
- A dose of 5 rem ↑ the risk of fatal cancer ~ 0.2%
- A dose of 25 rem ↑ the risk of fatal cancer ~ 1%

What are the Risks to Future Children? Hereditary Effects

- Magnitude of hereditary risk per rem is 10% of fatal cancer risk
- Risk to caregivers who would likely receive low doses is very small - 5 rem ↑ increases the risk of severe hereditary effects by ~ 0.02%
- Risk of severe hereditary effects to patient population receiving high doses is ~ 0.4% per 100 rem
- ↑ childhood cancer risk ~ 0.6% per 10 rem
Mass Casualties, Contaminated but Uninjured People, and Self Presenters

- An incident may create large numbers of:
  - contaminated people who are not injured &
  - worried people who may not be injured or contaminated.
- Triage Goal for mass casualty incident (MCI)
  - Evaluate & sort patients by immediacy of treatment
  - Do the greatest good for the most people
- Prevent overwhelming the ED

Goiânia: Lesson for RDD Preparedness

- Monitored: 112,000
- External And Internal Doses
  - Indicative: 249
  - Conclusive: 129
- Admitted To Hospital: 49
- Intensive Medical Care: 22
- Death: 4
- Forearm Amputated: 1

Handling of Mass Casualties

- Primary Assessment Center
- Controlled Triage Site
  - Triage For
    - Injury
    - Contamination
    - Perform minor treatment
    - Perform decontamination
- Area for deceased
- Emergency Department
  - Admit patients for treat & discharge
  - Ambulance Traffic Only
- Ambulance
- Traffic
- Only
- Community
- Access for:
  - Staff
  - Press
  - Officials
- Secondary Assessment Center

Triage Site

- Establish outside the ED
- Intercept the uninjured & worried
- Divert to Primary Assessment Center
Assessment Centers

• Staffing
  – Medical staff with radiological background
  – Health physicists, medical physicists
  – Psychological counselors
  – Security

• Activities
  – Screen for injury and contamination
  – First aid
  – Decontamination
  – Psychological counseling: staff & victims

Assessment Center Information

• Develop prepared information with Media Relations
• CDC website, “FAQ About a Radiation Emergency”

Systematic Approach

• Surveying
• Mass decontamination
• Resurveying
• Advanced decontamination
• Resurveying
• Additional decontamination or ED care
• Replacement clothing
• Transportation

Directions

• Clear directions
• Appropriate languages

Movement Through the Control/Decontamination Areas

• Clearly marked path
• Keep traffic moving in the right direction
• Prevent potentially contaminated individuals from walking into clean areas

Mass Decontamination Facilities

• Decontamination of large numbers of contaminated individuals should be carried out in existing shower facilities
  – fire house, school locker room, public campground
• Field decontamination capabilities – fire trucks
Second Stage Decontamination

- When preliminary decontamination not complete
- Second stage decontamination capability
- Specialized decontamination tent

Clothing for Decontaminated Individuals

- Provide patients exiting clean clothes
- Baggies for personal items, wallets, jewelry

Resurveying

- Resurvey after exiting the second stage decontamination capability
- If still contaminated, reroute through the second stage decontamination effort
- Try Phisoderm, Prell, Breck, or call REAC/TS
- Send to third stage (e.g., ED medical rad emergency room)

Contaminated Corpses

- Disaster Mortuary Operational Response Teams
- Restrict autopsies of highly radioactive corpses
- Radiation safety specialist assistance for:
  - Autopsies
    - Contamination control
    - Universal precautions
    - Avoid power saws
  - Assessment of cremation and burial on the environment

Psychological Casualties

- Fear of radiation and misunderstanding of consequences
- Long term psychological effects could arise 48-72 hours after an incident
- Counsel on acute & potential long term physical and psychological effects

<table>
<thead>
<tr>
<th>Anxiety disorders</th>
<th>Post traumatic stress disorder</th>
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</thead>
<tbody>
<tr>
<td>Depression</td>
<td>Traumatic neurosis</td>
</tr>
<tr>
<td>Insomnia</td>
<td>Acute stress disorder</td>
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</tbody>
</table>

Psychological Casualties

- Provide psychological counseling to staff, victims and their families
- High-Risk groups: emergency workers, children, mothers w/ small children, pregnant women & cleanup workers
- Provide exposed patients with a "sense of control of their health"

Resources:
- <www.usuhs.mil/psy/RDDFINAL.pdf>
- <www.ncptsd.org/terrorism/index.html>
Facility Recovery

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

Key Points

- Medical stabilization is the highest priority
- Pre-plan to ensure adequate supplies and survey instruments are available
- Train/drill to ensure competence and confidence
- Do what works for your facility and available resources
- Make sure that you have prepared your personal family plan - <www.ready.gov>
  <www.ucdmc.ucdavis.edu/are you prepared>

Key Points

- The First 24 Hours Are The Worst, Then
- Many Other Experts Will Be Available To “Help”
  - State Radiological Health
  - CDC
  - DOE
  - Many others

Radiological Medical Emergency Resources

- Required by Joint Commission on Hospital Accreditation
  - EC.1.4 Emergency Management Plan-facilities for rad/bio/chem
- NCRP 138, Management of Terrorist Events Involving Radioactive Material
- Radiation Emergency Assistance Center/ Training Site (REAC/TS)— website and training classes
- "Interim Guidelines for Hospital Response to Mass Casualties from a Radiological Incident," CDC website

Radiological Medical Emergency Resources

- NCRP 111, Developing Radiation Emergency Plans for Academic, Medical or Industrial Facilities
- "Protecting People Against Radiation Exposure in the Event of a Radiological Attack," ICRP – to be issued
- Public Protection From Nuclear, Chemical, & Biological Terrorism (Med Physics Pub)

Radiological Medical Emergency Resources

- "Disaster Preparedness for Radiology Professionals"
- ACR website
  - Business Practices, Disaster Preparedness
  - Free pdf
Radiological Medical Emergency Resources

- "Medical Management of Radiation Accidents," 2nd edition, Gusev, Guskova and Mettler


Additional 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.afri.usuhs.mil>
  - Medical Management of Radiological Casualties Handbook, 2003; and Terrorism with Ionizing Radiation Pocket Guide

- Websites:
  - <www.bt.cdc.gov/radiation> - Response to Radiation Emergencies by the CDC
  - <www.acr.org> - Disaster Preparedness for Radiology Professionals by ACR
  - <www.va.gov/emshgp> - Medical Treatment of Rad Casualties

Who Can Help

- State Radiological Health Branch – Health Services
- State Department Emergency Management
- Center for Disease Control
  - Medical treatment advise & decon
  - Strategic Stockpile
  - Population monitoring
- Department of Energy
  - REAC/TS
  - Radiological Assessment Program (RAP)

Plume Mapping Using “HOTSPOT”

http://www.llnl.gov/nai/technologies/hotspot/

Websites

CDC Website

Visit http://www.bt.cdc.gov/radiation

REAC/TS Website

Visit http://www.orau.gov/reacts
Websites

Visit http://hps.org/hsc/responsemed.html

Websites

Visit http://hps.org/hsc/documents/emergency.ppt

Somebody has to do something........
And it's incredibly pathetic that it has to be us.

JERRY GARCIA