Radiation Exposure, illness and injury

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Medical Treatment for Radiological Casualties

- Acute Radiation Syndrome (ARS)
- Acute Local Radiation Injury
- Internal contamination (inhalation or ingestion)
- Cutaneous Syndrome
- Combined Injury (Radiation + trauma)
Acute Radiation Syndromes

Subclinical ........ 0 – 1 Gy

Hematopoietic......1-8 Gy

Gastrointestinal......8-30 Gy (expectant)

Neurovascular.....> 30 Gy (expectant)

Severe Local Radiation Injury..> 3 Gy

Combined Injury Syndrome
Sensitivity of Cells to Ionizing Radiation

**More Radiosensitive**
- Mature Lymphocytes*
- Spermatogonia
- Myeloblasts
- Intestinal Crypt Cells
- Epidermal Stem Cells
- Endothelial Cells
- Gastric Gland Cells
- Osteoblasts
- Chondroblasts
- Spermatocytes
- Granulocytes
- Osteocytes
- Spermatozoa
- Erythrocytes
- Fibrocytes
- Chondrocytes
- Muscle Cells, nerve cells

**In general,**
- Undifferentiated
- Divide quickly
- High metabolic activity

**Less Radiosensitive or “Radioresistant”**
- In general,
  - Differentiated
  - Slow or no division
  - Slower metabolism
Animal Response to Radiation: Terminology

- **LD$_{50/30}$ or LD$_{50/60}$** - dose necessary to cause 50% death in an irradiated population in 30 and 60 days respectively, without treatment.

  - For radiation, acute whole body dose:
    - $\text{LD}_{50/60} = 350-400 \text{ rad} = 3.5-4.0 \text{ Gy}$

- Deterministic effects – early or late effects that have dose-effect relationship, *i.e.*, a threshold dose – increase in effects with increasing dose.
Prodromal Signs and Symptoms of High Level Radiation Exposure

- Anorexia
- Nausea
- Vomiting
- Diarrhea
- Fever
- Conjunctivitis
- Skin erythema
Triage by Multi-Parameter Techniques

- Time to onset and severity of nausea and vomiting.

- Decline in absolute lymphocyte count over several hours or days after the exposure.

- Appearance of chromosome aberrations (including dicentrics and ring forms) in peripheral blood lymphocytes.

- The medical history is essential for triage of victims, selection of therapy, and assignment of prognosis.
Vomiting induced by exposure to ionizing radiation occurs in a fraction of exposed humans (Goans et al., in press).
Time to Emesis as a Function of Dose

TIME TO EMESIS POST-ACCIDENT

REAC/TS ACCIDENT REGISTRY (N = 108)
One Effective ED Triage

- Simple, multi-parameter screen at point of triage. A simple score has been found to be very sensitive:
  
  \[ R = \frac{N}{L} + (\text{emesis}) \]

- \( N = \) absolute neutrophil count and \( L = \) absolute lymphocyte count. \( N/L \) ratio median is 2.21 from controls. Emesis (2 points if yes, 0 if no).

- Test is valid for Dose > 1 Gy and time > 4 h post-incident.
An Example

- UT CARL Radiation Accident 2/4/1971

- Variable Dose Rate Irradiation Facility (VDRIF); Co-60 source; ~63 TBq (7700 Ci).

- 1.44 Gy midline dose by cytogenetics; estimated 2.6 Gy skin dose. Emesis x 4.

<table>
<thead>
<tr>
<th>Time post-accident</th>
<th>N/L</th>
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<tbody>
<tr>
<td>Immediate</td>
<td>1.69</td>
</tr>
<tr>
<td>4.5 h</td>
<td>15.2</td>
</tr>
</tbody>
</table>
Systemic Effects of Hematopoietic Syndrome

- Stem cell depletion
- Neutropenia and often pancytopenia
- Increased infectious complications - sepsis
- Hemorrhage
- Anemia
- Impaired wound healing
Haematopoietic syndrome

Normal bone marrow cells
Survival potential

Bone marrow damaged by radiation injury
Hematological response to 1-3 Gy, whole body exposure to ionizing radiation
Effects of Gastrointestinal Syndrome

- Malabsorption
- Ileus - vomiting; GI distention
  - fluid and electrolyte shifts
  - dehydration
  - acute renal failure
  - cardiovascular collapse
- GI bleeding
Neurovascular Syndrome

- Vomiting and diarrhea within minutes
- Confusion and disorientation
- Severe hypotension
- Cerebral edema
- Convulsions - coma
- Hyperpyrexia
- Fatal within 24 to 48 hours
Pu Sphere with Tungsten Carbide Reflector: Los Alamos-1
21 August 1945

Day 24

ACUTE LOCAL IRRADIATION

- 3 Gy threshold - Epilation beginning around day 17.

- 6 Gy threshold - Erythema; distinguish from thermal burn; minutes to weeks post-exposure, depending on dose.

- 1,0- 15 Gy - Dry desquamation.

- 20- 50 Gy - Wet desquamation, 2-3 weeks post-exposure, depending upon dose.

- >>50 Gy - radionecrosis, deep ulceration.
Approximate Surface Dose From Common Gamma Emitters

- $^{60}\text{Co}$ - 3100 rad/min/Ci (0.84 Sv/min-GBq).
- $^{137}\text{Cs}$ - 770 rad/min/Ci (0.21 Sv/min-GBq).
- $^{192}\text{Ir}$ - 1200 rad/min/Ci (0.32 Sv/min-GBq).
- $^{226}\text{Ra}$ - 1900 rad/min/Ci (0.51 Sv/min-GBq).
Questions?
RADIATION EMERGENCIES: 
WHAT DO WE KNOW? 
WHAT DO WE NEED TO KNOW?

Translating Knowledge into Action 
in the Emergency Department
Team Physician, Canadian Medical Assistance Teams (CMAT) team, Ishinomaki, Japan, March 22-28, 2011

Emergency Physician and Medical Director, Emergency Department Disaster Preparedness, QEII Health Sciences Centre, Halifax, NS

Medical Emergency Treatment for Exposures to Radiation

Original faculty METER course, Department of Health
Why is my hospital not prepared?

- Idiosyncratic: is this problem unique to my hospital?
  - No

- Slow process of learning who does what, how, why

- Health care delivery
  - in an Emergency Preparedness model
  - In the Public Health sphere
Perspective
Who is involved in Disaster Preparedness?

Managers

First Responders → Managers

Managers → First Receivers

First Receivers → First Responders
Managers

- Who are they?
  - Professionals in Disaster Preparedness

- Expertise
  - Disaster management

- Role when disaster happens?
  - Establish EOCs, inform and enable decision makers
  - Repairing and maintaining critical infrastructure and services

- Access to information
  - High
First Responders

- **Who are they?**
  - Paramedics, Fire and Police medics

- **Expertise**
  - Pre-hospital medical stabilization

- **Role when disaster happens?**
  - Triage
  - Treatment
  - Transportation

- **Access to information**
  - Moderate
First Receivers

- **Who are they?**
  - Emergency Department MDs, RNs, paramedics, patient attendants, clerks

- **Expertise**
  - Heart attacks, broken arms, appendicitis

- **Role when disaster happens?**
  - Provide clinical care for unfamiliar problems in an unfamiliar context

- **Access to information**
  - Low
What are options for training?

<table>
<thead>
<tr>
<th></th>
<th>Managers</th>
<th>First Responders</th>
<th>First Receivers</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>CBRNE</strong></td>
<td>CEMC¹</td>
<td>CEMC</td>
<td>None²</td>
</tr>
<tr>
<td><strong>Radiation</strong></td>
<td>CEMC, METER³, REAC/TS</td>
<td>METER REAC/TS</td>
<td>METER REAC/TS</td>
</tr>
<tr>
<td><strong>All-Hazards Disaster Response</strong></td>
<td>CEMC</td>
<td>CEMC</td>
<td>None</td>
</tr>
</tbody>
</table>

1. Canadian Emergency Management College in Ottawa
2. PHAC online course in Basic CBRNE preparedness
3. Currently being re-offered on a case-by-case basis
"Our EOC will figure it out for us"

"We can’t afford to exercise"

"We’re too busy to exercise"

"We’ve always managed in the past"

"A major CBRNE event is highly unlikely"
Our plan in Halifax

ED setup for a Radiation Disaster

Main entrance

Control line

Contaminated Treatment Area (only for radiation)

Ambulances: Ambulance Bay used for TRIAGE and DECON

Walk-ins: Ambulance Bay used for TRIAGE and DECON

Ambulance Bay

Transfer Bay (can set up decon shower as needed)

7 showers in Ambulance Bay

Single shower in patient decon room

CBRN Triage
Management of patients exposed to or contaminated with radiation

**Unstable patients** (CTAS 1 and 2)
- These patients require urgent or emergent assessment and treatment. Their care should not be delayed to wait for decontamination prior to being brought into a treatment room. They should be brought into a **contaminated treatment room** (see below)

**Stable patients** (CTAS 3, 4 and 5)
- These patients should be decontaminated prior to being brought into a treatment room. Once they have been decontaminated they can be brought into the ED. If there are multiple patients who have been decontaminated and/or exposed to radiation, they should be cohorted in the ED.

**Walk-ins**
- Potentially contaminated and/or exposed casualties should always have emergent medical problems managed immediately, since medical instability ALWAYS takes precedence over contamination issues. Triage paramedics should put on PPE, and then assess patient’s vitals. If the patient is stable and it isn’t known whether they are contaminated, have them put a gown on over their clothes and some booties, then walk them (or wheel them in a wheelchair) through the ED to the decon room (in the Ambulance Bay).

**EHS transports**
- EHS policy is not to transport contaminated casualties
Sources of Contamination

Steam and Smoke

Cooling water
How to assess risk before going?

- What are the current radiation levels?
  - Official sources (Tepco, NISA, IAEA)
  - Data from existing ground and air sensors

- What’s the worst thing that could happen?
  - Loss of containment of RPV (reactor pressure vessel) and PCB (primary containment building)
  - Meltdown (≠ supercriticality, explosion)
Information was lacking...
Then, on Friday Mar 18

http://eq.wide.ad.jp/index_en.html

### Readings at Monitoring Post out of 20 Km Zone of Fukushima

<table>
<thead>
<tr>
<th>Monitoring Post (length from NPP)</th>
<th>Monitoring Time</th>
<th>Reading (unit: µSi/h)</th>
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</thead>
<tbody>
<tr>
<td>Reading Point 1 (about 80Km North/West)</td>
<td>2011/3/18 10:08</td>
<td>8.5 *2</td>
</tr>
<tr>
<td>Reading Point 4 (about 50Km North/West)</td>
<td>2011/3/18 10:55</td>
<td>5.7 *2</td>
</tr>
<tr>
<td>Reading Point 31 (about 30Km West/Northwest)</td>
<td>2011/3/18 11:20</td>
<td>40.0 *2</td>
</tr>
<tr>
<td>Reading Point 10 (about 40Km North/West)</td>
<td>2011/3/18 11:29</td>
<td>4.0 *2</td>
</tr>
<tr>
<td>Reading Point 32 (about 30Km North/West)</td>
<td>2011/3/18 11:33</td>
<td>140.0 *2</td>
</tr>
</tbody>
</table>

How much is 140µSi/hr?

Equivalent to 1 chest X-ray per hour, or 1 CT abdomen every 2 days.
Monitoring post locations
Is this information available in Canada?

- Network of permanent (and temporary) monitors in Canada
- BC-CDC was unable to obtain data from monitors on Vancouver Island from Canadian government for 1 week
- Alternate sources
  - [https://pachube.com/](https://pachube.com/)
  - Local surveys
Assessing for contamination

- **PAD (Personal Alarming Dosimeter)**
  - Dose rate alarm set at 10 μSv/hr; never showed more than 1 μSv/hr, usually zero
  - Total dose alarm set at 100 μSv (measured ≤20μSv over six days, Mar 24-29)

- **TLD (Thermal Luminescence Dosimeter)**
  - 2 units (personal and control); results pending
  - Most of total exposure was from flights

- **Geiger Counters**
  - For assessing ground deposition
Know what the units mean
Assessing change in ambient levels

- Periodic surveying of door mat into tent, soles of boots (i.e. every morning and evening)
- Levels (counts per minute) using Geiger Counter
  - My back yard in Halifax: 50 cpm
  - My brothers house in Vancouver: 30 cpm
  - Hostel in Tokyo: 30 cpm
  - Starbucks in Tokyo: 80-100 cpm
  - Levels in Ishinomaki: 100-200 cpm
Plan if sudden spike in readings

1. Confirm readings
2. Try to identify point source if present
3. Put on PPE
4. Take KI (130mg po OD), give preferentially to youngest team members if scarce
5. Try to determine reason for spike, expected course of events
6. Activate plan for withdrawal from region
Why we aren’t prepared

1. Perspective
   - We all need to be involved

2. Training
   - First responders need more opportunities

3. Standards
   - Accreditation Canada standards need to be functional
Why we aren’t prepared

4. Funding
   - We are now going into a deficit reduction period

5. Willingness to ask difficult questions
   - Are we prepared?
   - What do you need to be prepared?
Thank you!

Proudly leading the World in Minimally Invasive Lobster Surgery
Emergency Management Branch
Ministry of Health and Long-Term Care
February 24, 2012

Radiation Health Response Plan
Outline

- About EMB
- Nuclear Industry in Ontario
- Radiation Health Response Plan
- CBRN Emergency Preparedness Program
Emergency Management Branch - MOHLTC

- Created in 2003 to support emergency management activities within the Ministry and the health care system.

- Responsible for developing policies, plans and procedures to strengthen the ministry’s health emergency response capability.

- Coordinate the implementation of programs.

- Responsible for activating and managing the Ministry Emergency Operations Centre (MEOC) and implementing the Incident Management System (IMS).
Radiation/Nuclear Planning Considerations

- Of the 18 active power reactors in Canada, 16 are in Ontario.

- Ontario has three nuclear power plant sites and three research reactors.

- Fermi 2 nuclear facility in Michigan (a portion of Ontario, including Amherstburg, also falls within the Primary Zone).
Radiological/Nuclear Threat Assessment

• EMB conducts a provincial MOHLTC HIRA annually

• Radiological and Nuclear hazards identified
  – Accidental:
    ▪ transportation accident, power generating/research facility accident
  – Intentional:
    ▪ war/terrorism

• Probability: low-moderate due to safeguards in place

• Consequence: severe-catastrophic
Provincial Radiological/Nuclear Planning

• The Provincial Nuclear Emergency Response Plan (PNERP) developed pursuant to s.8 *Emergency Management and Civil Protection Act.*

• Within PNERP:
  – Ministry of Health and Long-Term Care (MOHLTC) required to develop and maintain a plan for management of patients exposed to high levels of radiation.
  – Ontario’s Radiation Health Response Plan (RHRP).
Provincial Roles & Responsibilities in RN Incidents

• All emergencies are local…except radiological/nuclear!

• Major R/N incident triggers immediate provincial emergency declaration upon confirmation.
  – MOHLTC implements RHRP.
  – MOHLTC receives Technical Advice from R/N medical experts.
  – Chief Medical Officer of Health issues directives as appropriate.
MOHLTC Roles & Responsibilities in RN Incidents

• MOHLTC is responsible for leading the health response to support and maintain local health services through implementation of the RHRP:

  – The coordination of health organizations to deal with potentially exposed and/or contaminated persons.

  – Providing advice to local authorities regarding the need to implement protective measures by the public to protect public health, and take appropriate related actions.

  – Decision-making regarding the distribution of KI.

  – Oversee the required arrangements for follow-up medical monitoring, care and rehabilitation for those with significant irradiation exposure.
Radiation Health Response Plan (RHRP)

- The RHRP is designed to guide planning at both the provincial and local levels across Ontario, the plan outlines:
  - How Ontario’s health care system will respond to a radiological/nuclear event; and,
  - The conditions under which precautionary and protective actions will be ordered for the general public and health workers.

- The plan will balance between providing direction to ensure consistency while maintaining local flexibility.

- The RHRP will be an evergreen document.
RHRP Scope

- The plan outlines response activities to support the coordination of health organizations to deal with potentially exposed and/or contaminated persons following a radiological/nuclear event.

- Covers events that occur inside the province as well as those that take place outside but may have health impacts within Ontario.

- This is a health coordination plan that provides direction to the health care sector, emergency procedures and plans need to be further developed at the local level to support this plan.
The RHRP covers:
• Overall purpose, goals, and scope
• Radiation 101
• Planning Scenarios and Risk Assessments
• Roles, responsibilities, and functions:
  – MOHLTC
  – Emergency Medical Services (EMS)
  – Public Health Units
  – Acute Care Services

• Planning and Response:
  – Screening, Monitoring, and Decontamination
  – Pre-Hospital and Hospital Triage and Treatment
  – Precautionary and Protective Measures
  – Psychosocial

• System-wide tools:
  – Occupational Health and Safety
  – Supplies and Equipment (Hospitals, EMS, PHUs)
  – Communications

• Potassium Iodide (KI) Guidance
RHRP Work Groups

• Work groups:
  – EMS and Hospitals; MDUs; Community Response; KI Policy; Occupational Health & Safety.

• Work Groups representation: Nuclear establishments, ministries, municipalities, public health units, Public Health Ontario, industry experts.
  – EMB is collaborating with workgroups to further develop sections within the RHRP.

• Final Reference Group Review.
  – Group will provide a final review and edits to RHRP.
  – EMB to incorporate edits and finalize document.

• A final plan is forecasted to be completed by Spring 2012.
Possible Public Health Role in RN Incident

• The following are possible roles for public health units during a radiological/nuclear incident:
  – Distribution of KI prophylaxis.
  – Provide support to Community Emergency Management Coordinators from a public health perspective.
  – Align local communication with PEOC and CMOH direction regarding precautionary and protective actions.
  – Health inspection of sanitation, food, water, and air at reception and evacuation centres.
Public Health Unit Planning

- Many public health units have not been as involved in planning for radiological/nuclear emergencies as health units with nuclear reactor facilities within their jurisdiction have, e.g., Durham Region, Grey-Bruce.

- Public health units should take an active role in planning for all types of radiological hazards, and assessing RN risks in communities (e.g., non-facility based incidents).

- As part of the roll-out of RHRP, training opportunities will be provided to public health units to support their role in R/N events.
CBRN Emergency Preparedness Program

• Started 2005, a 3 year plan to strengthen health sector capacity to respond to a Chemical, Biological, Radiological, or Nuclear (CBRN) events.
  – Ensures the consistent practices and interoperability across Ontario to support a seamless response in an emergency.
  – Ensures the protection of patients and staff.

• Acute hospitals, public health units, and emergency medical services were equipped with CBRN equipment.
  – Hospitals, public health units, and emergency medical services received different types of equipment based on their role in an event.
  – Role out included training sessions to support the use of the equipment.
CBRN Emergency Preparedness Program

Hospital Equipment / Training Received:

• Decontamination tent plus related decontamination and spill control products.

• PPE: Level C apparel, hand protection, and respiratory protection.

• Radiation detection equipment.

• Hospitals expected to maintain supply levels and training after roll-out of program; ministry investment a one-time resource.

• One-time train the trainer training offered.
Public Health Unit Equipment / Training Received:

- Personal Protective Equipment, e.g., protective apparel, hand protection and respiratory protection.
- Crowd Control Items.
- Electronic Personal Dosimeters.
- Communication, e.g., two-way FMRS/GMRS radio set.
- Training on awareness, equipment use, and potential role of public health in a CBRN event.
CBRN Emergency Preparedness Program

• Program is currently under review for the following reasons:
  – Challenges to hospitals and public health units in maintaining capacity and expertise without training opportunities.
  – Best practices for first receivers is an evolving practice.
  – Expiry of select supplies and equipment.

• Work in underway to update the current CBRN Emergency Preparedness Program that will address training and equipment needs.
Contact Us

Emergency Management Branch
416-212-0822 or Emergencymanagement.moh@ontario.ca

24 Hour Healthcare Provider Hotline
1-866-212-2272

Website