Acute Radiation Medical Management

Radiation is a process in which energy travels through space. There are two types of radiation: **non-ionizing** (low energy) and **ionizing** (sufficient energy to break molecular bonds and create chemical changes). Ionizing radiation travels under the form of particles (alpha, beta, neutron) or waves (gamma rays and x-rays). The Gray (Gy) unit represent the energy absorbed per unit of mass and is called the absorbed dose, whereas the measure of biological effect on human tissue is called the equivalent dose and expressed as sieverts (Sv).

In humans, ionizing radiation may lead to double-strand breaks in DNA, causing chromosomal aberrations and either lethal cellular damage (deterministic effects) or cellular mutation (stochastic effects). Deterministic effects are directly proportional to the dose of radiation and are responsible for injuries such as burns, cataracts and sterility, whereas the probability of stochastic effects increase with the dose, e.g. cancer.

Radiological/Nuclear events may be of two natures, resulting from accidental spill of radioactive material (eg. nuclear reactor) or from a terrorist event (Radiological Dispersing Device [RDD], Radiological Exposure Device [RED], low-yield nuclear weapon). If one of these events were to happen, patients could potentially be contaminated or exposed to radiation.

Contamination occurs when an outside radiological source releases radioactive material deposited on the skin (external contamination) or inhaled/ingested/absorbed through wounds into internal organs (internal contamination). **Radiation exposure** happens when human tissues absorb penetrating radiation from an outside source or can also occur after internal contamination. If the dose of radiation is sufficient, acute radiation syndrome may result from radiation exposure.

Acute radiation syndrome (ARS) manifests itself initially with a prodrome phase consisting of nausea, loss of appetite, vomiting, fatigue, and diarrhea. The latent phase, a symptom-free period of variable duration according to the radiation dose, then follows. This absorbed dose is also responsible for determining one of the three subtypes of syndrome that follows the latent phase: *hematopoietic syndrome* (1-6 Gy), *gastrointestinal syndrome* (> 6 Gy) and *cerebrovascular syndrome* (20-30 Gy). *Cutaneous syndrome* may also occur if a large area of skin has been exposed to high amount of radioactive particles, which don't penetrate deeply enough in skin tissue to cause the other subsyndromes of ARS.

In the event of a radiological/nuclear disaster, on-scene medical responders should be responsible for immediate first aid and emergency care of critical injuries, transport of casualties to hospital and decontamination or transport to decontamination center of non-critically injured victims. EMS responders should be aware that there is minimal radiological risk for them if they wear adequate protective equipment and follow the instructions of the radiological team on site to minimize cross-contamination.

Once in the hospital, medical staff should also be wearing adequate protective equipment; universal precautions are usually sufficient (face shield, eyewear, barrier gown and gloves). Potentially contaminated patients and health care workers transitioning from a "clean" to a "dirty" area should be surveyed with a Geiger-Müeller counter to determine their equivalent

dose. An area or a person is considered decontaminated when the levels are less than three times the usual background radiation dose.

The priorities for physicians in the Emergency Department are to address medical and surgical issues in unstable patients first, then move on to decontamination and assessment for internal contamination. Procedure demonstrations on adequate personal protection equipment, safely handling patients and decontaminating wounds and intact skin can be accessed on the Radiation Emergency Assistance Center/Training Site (REAC/TS) website from the Oak Ridge Institute for Science and Education at http://orise.orau.gov/reacts/resources/guide/procedures.htm.

If **internal contamination** is suspected, bioassay samples should be collected (nasal swabs, skin swabs, emesis, urine, stools) and surveyed with a Geiger-Müeller counter. The type of isotopes should try to be identified to administrate the appropriate decorporating agents, which will decrease uptake in circulatory system and the deposition in organs as well as increase excretion. A list of decorporating agents and corresponding adult/pediatric doses can be found on the Radiation Emergency Medical Management (REMM) website from the US Department Health & Human Services at http://www.remm.nlm.gov/Countermeasures.pdf.

If **radiation exposure** is suspected, a complete blood count (CBC) should be drawn immediately and then monitored closely every 4-6 hours. A dicentric chromosome assay should also be sent to one of the centers that conduct biological dosimetry (see contact list below). The radiation dose should be estimated to guide treatment and prognosis, as an absorbed dose over 10 Gy approaches 100% mortality even with adequate medical treatment. A useful online tool to assess the dose from exposure according to the time of onset of vomiting and the lymphocyte depletion kinetics can be found on the REMM website at http://www.remm.nlm.gov/ars_wbd.htm#lymphocyte.

Physicians should assess for ARS and the 4 subsyndromes through history and physical exam. The severity of these symptoms will help indicate the “response category” for an individual patient and determine the subsequent management (ambulatory versus hospitalization and routine care versus critical care). Again, an interactive tool is available on the REMM website (http://www.remm.nlm.gov/ars.htm) to guide appropriate treatment and determine response category.

The treatment of ARS consists mainly of supportive care through IV fluid support, antiemetic (ondansetron) and antidiarrheal (loperamide) medications, broad-spectrum antibiotics, antifungal and antiviral when infections are suspected, adequate analgesia and topical treatment of cutaneous syndrome. Early hematopoietic stem cell transplant may be considered if a donor is available.

Contact List:

National Biological Dosimetry Response Plan
(http://www.hc-sc.gc.ca/hc-ps/pubs/ed-ud/newsletter-bulletin-4/national_plan-eng.php)
Contact person: Ruth Wilkins
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Radiation Emergency Assistance Center/Training Site (REAC/TS)
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PO Box 117, MS-39, Oak Ridge, TN 37831
http://orise.orau.gov/reacts/

References:

Radiation Emergency Medical Management: REMM (US Department of Health and Human Services). Last updated Apr 07 2011. Accessed on Jun 09 2011 at http://remm.nlm.gov

REMM algorithms and online tools also available for download to computer/mobile device at http://www.remm.nlm.gov/Aboutthissite.htm#download

International Safety Research for CBRN Research & Technology Initiative. R/N Medical Emergency Response Training Course ISR Report 4004-01. September 2007.

ORISE: Radiation Emergency Assistance Center/Training Site (REAC/TS) (US Department of Energy). Accessed on Jun 09 2011 at http://orise.orau.gov/reacts/