Radiation Injury Treatment Network®

Fact Sheet for Health Care Professionals on Radiation Injury and Stem Cell Transplantation

Hematologists, oncologists and hematopoietic cell transplant specialists are likely to play a role in the treatment of casualties exposed to radiation. Thus, the Radiation Injury Treatment Network (RITN), National Marrow Donor Program (NMDP) and the U.S. Navy developed a contingency plan to guide the response of NMDP centers to radiation incidents. This fact sheet is an introduction to radiation incidents and to some of the medical issues involved in managing radiation casualties.

A radiation incident is any occurrence, whether deliberate or accidental, which results in non-medical exposure to radiation, whether internal or external exposure. Radiation incidents could be acts of terrorism, involve the military (*e.g.* nuclear war), or result from accidents at civilian nuclear reactors or other facilities. In any event, casualties from a radiation incident may be military personnel, civilians, or both.

What is radiation?

Radiation includes high-energy electromagnetic waves like x-rays or gamma rays and high-energy particles (*e.g.*, alpha or beta particles). The release of radiation energy can be very rapid and violent, such as during a nuclear explosion, or slow and steady, such as from the natural decay of Cesium or Uranium. A type of nuclear transformation that takes place at speeds between these two extremes is a “criticality accident.” In this situation, a mass of radioactive materials achieves enough energy to decay rapidly, with the resulting radiation stimulating even more decay, which ultimately generates a short burst of radiation energy. The 1986 accident at Chernobyl was a criticality accident, as was the 1999 accident at a nuclear processing facility in Japan.

Because radiation is genotoxic, whenever individuals come in contact with radiation, their risk for developing cancer and non-malignant complications may increase. Incidental exposures, especially minor exposures spread out over time, increase risk only slightly. Larger exposures lead to larger increases in risk.

Acute radiation syndrome (ARS) may develop when significant doses of radiation are received in a short period of time. Classically, ARS primarily involves 4 organ systems: hematologic, dermatologic, gastrointestinal and neurologic. The hematologic system is particularly sensitive to radiation, so some casualties will develop hematologic toxicity after receiving doses lower than those necessary to develop other toxicities. RITN, the NMDP and the U.S. Navy have developed a contingency plan for responding to a mass casualty radiation event that focuses on casualties with hematologic ARS.

Acute radiation syndrome

ARS develops in three stages: initial (or prodromal), latent, and manifest illness, followed by either recovery or death (Figure). The initial stage commonly lasts 1-2 days, during which the victim may experience nausea, anorexia, vomiting, and diarrhea. Radiation dose can be estimated based on the length of time between exposure and the onset of these initial symptoms. The sooner these symptoms appear, the greater the radiation dose received. Peripheral blood counts (especially lymphocytes) are extremely sensitive to radiation, declining in proportion to the amount of whole-body radiation. Tracking these counts over time is another way to estimate whole-body radiation dose. Interactive online tools using lymphocyte kinetics and time to vomiting, as well as extensive background and guidance on event management are available on the Radiation Emergency Medical Management Website (www.remm.nlm.gov) maintained by the National Library of Medicine.

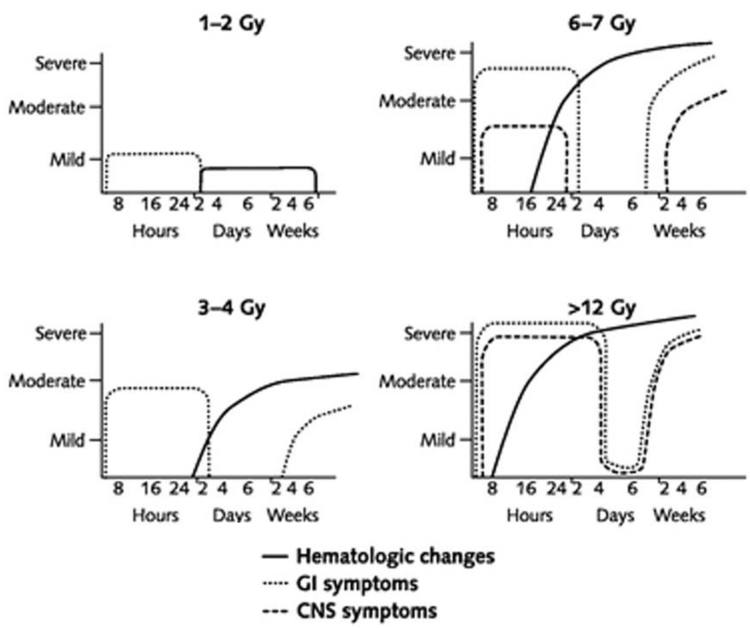

Figure. Expected time course of radiation injury after different whole-body dose exposures. Severity of injury (y-axis) is on an arbitrary scale. Modified from Waselenko et al. 2004.

Outward symptoms of ARS that develop during the initial stage may abate during the subsequent latent stage, but blood cell counts will continue to decline (Figure). The duration of the latent stage is inversely proportional to the radiation dose, with high exposures (8 Gy whole-body dose or higher) resulting in little or no latent stage. In contrast, casualties who received lower exposures may have days or weeks of latency before developing significant myelo-suppression.

In the manifest illness stage, casualties are at risk for complications of myelosuppression and may also develop toxicity of other organ systems, including the gastrointestinal tract, lungs, liver, brain and skin. Severe multi-organ involvement portends a particularly poor prognosis, even with aggressive management.

Managing marrow toxicity after a radiation incident

In a radiation incident, casualties will suffer a range of exposures. Many who received high doses will die from their radiation injuries. The causes of death vary, but they include infection, hemorrhage, organ failure, neurovascular collapse, and burns. In contrast, most casualties who received lower doses (less than 2 Gy) will spontaneously recover without medical intervention. Those who received intermediate doses may be salvageable with aggressive supportive care. Casualties with the combination of radiation injury plus trauma and/or burns may be particularly difficult to manage and have a worse prognosis. Burns can result either from an explosion, radiation itself, or secondary fires that develop in the aftermath of the radiation incident.

The management of casualties with marrow toxicity is very similar to the management of patients treated with myelosuppressive cancer therapy, and includes antibiotics, myeloid cytokines (*e.g.* G-CSF, GM-CSF) and other aspects of supportive care. A small fraction of radiation casualties may be essentially myeloablated, and thus potential candidates for hematopoietic cell transplantation. However, some within this range of radiation exposure may also have physical trauma, burns, infection, and/or radiation toxicity to other organ systems. These complications can markedly reduce the likelihood of survival after hematopoietic cell transplantation and may preclude the use of chemotherapy and immunosuppressants to promote engraftment and minimize graft-versus-host disease.

In consultation with the Department of Health and Human Services, European partners, and the U.S. Navy, RITN has developed guidelines for the management of casualties with hematologic ARS (www.ritn.net). The guidelines include algorithms for triage and the selection of casualties for myeloid cytokines, HLA-typing and hematopoietic cell transplantation.

The NMDP expects that any radiation incident resulting in significant casualties will lead to an increase in Registry searches and donor activations. The NMDP and the U.S. Navy have contingency plans in place to accommodate this increased activity. If any casualties ultimately require a stem cell transplant, the NMDP is prepared to search its registry for matched donors. As of November 2010, the NMDP Registry contained over 8.8 million potential stem cell donors and more than 140,000 cord blood units, the largest source of blood stem cell donors in the world.

Further information

Web sites:

Radiation Injury Treatment Network Web site: www.ritn.net

Radiation Emergency Medical Management Web site: www.remm.nlm.gov

U.S. Centers for Disease Control and Prevention (CDC) Web site: www.cdc.gov

Agency for Toxic Substances and Disease Registry (ATSDR) Web site: www.atsdr.cdc.gov

World Health Organization – Radiation Emergency Preparedness and Assistance Network (REMPAN) Web site: www.who.int/ionizing_radiation/a_e/rempan/en/

Radiation Emergency Assistance Center/Training Site (REAC/TS) Web site: http://orise.orau.gov/reacts/

Medical literature:

Bader JL, Nemhauser J, Chang F, Mashayekhi B, Sczcur M, et al. Radiation Event Medical Management (REMM): Website Guidance for Health Care Providers. Prehosp Emerg Care 2008;12:1-11.

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DHS (2009) Planning Guidance for Response to a Nuclear Detonation. Department of Homeland Security. Available at: http://www.hhs.gov/disasters/discussion/planners/planningguidanceforresponse.pdf.

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Waselenko JK, MacVittie TJ, Blakely WF, Pesik N, Wiley AL, et al. Medical management of the acute radiation syndrome: recommendations of the Strategic National Stockpile Radiation Working Group. Ann Intern Med 2004;140:1037-1051.

Weinstock DM, Case C, Bader J, et al. Radiologic and nuclear events: contingency planning for hematologists/oncologists. *Blood* 2008;111(12):5440-5.