Biological Effects from Acute Exposures

Professional Personnel

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Fact Sheet #11

Division of Environmental Health
Office of Radiation Protection

Washington State Department of Health

ASSESSMENT AND TREATMENT OF RADIATION INJURY

Emergency personnel may be required to perform duties in a nuclear radiation environment. An accident may already have occurred, resulting in the spread of contamination, or there may be the potential for exposure. Operational considerations may require that emergency response be conducted in that environment for a protracted period of time. It is critical that all personnel be protected to reduce or avoid short-term, or acute, exposures to radiation. The Office of Radiation Protection serves as a resource for consultation on matters related to the effects of radiation. Our activities involve working with emergency and medical personnel to coordinate resources necessary to determine or assess the effects of radiation exposure.

BIOLOGICAL EFFECTS

The average person in the U.S. is exposed to background radiation levels that would result in an annual dose of approximately 360 mrem. Higher and more short-term doses, although unlikely, are termed acute exposures. Whole-body doses of radiation (of the type in x-ray or gamma radiation) in significant doses of 35 rad can cause nausea, weakness and appetite loss within a few hours following an acute exposure. These symptoms will disappear within a few hours of the exposure.

After doses of 50 rad or above from acute radiation exposures, many immune competent cells are used up defending the body from infection, and others are prevented from performing their duty. Virtually no new replacement cells are produced because of the extensive damage to stem cells in bone marrow. At doses between 125 – 300 rad, there is increasing likelihood of severity of nausea, vomiting and weakness

with symptoms persisting for up to two days. There is 50% mortality from acute exposures greater than 350 rad without medical treatment.

Infection is the main cause of death after an acute exposure to radiation. However, cells differ in their sensitivity to ionizing radiation damage. The loss of a specific component could lead to an overall failure in the defense mechanism.

Radiation Effects Following Acute Exposures In Rads To Target Organs		
Exposure Health Effect	**Organ**	**Absorbed dose in Rad**
Temporary Sterility	Testes	15
Nausea	Whole Body	35
Depression of Blood Cell Forming Process	Bone Marrow	50
Reversible Skin Effects (e.g., early reddening)	Skin	200
Permanent Sterility	Ovaries	250-600
Vomiting	Gastrointestinal Tract	300
Temporary Hair Loss	Skin	300-500
Permanent Sterility	Testes	350
Skin Erythema	Skin	500-600

Reference: NCRP Report No.138

Biological Effects of Short Term Radiation on Humans	
Dose (Rad)	**Effect**
0-20	No detectable effects
20-100	Measurable transient blood changes. Temporary decrease in white blood cell count.
100-200	Acute radiation sickness - nausea, vomiting, longer-term decrease in white blood cells.
200-300	Vomiting, diarrhea, loss of appetite, listlessness, death in some cases.
300-600	Vomiting, diarrhea, hemorrhaging, deaths occurring in 50% of cases at 350 rad or above without medical treatment.
Above 600	Eventual death in almost all cases

PRECURSOR SYMPTOMS

Symptoms that precede the onset of radiation sickness will arise soon after an exposure to ionizing radiation include, nausea, vomiting, diarrhea, fatigue and disorientation. Medical personnel will address the first three symptoms (emesis), since they are the most common and can occur even at moderate, sublethal doses.

Gastro-intestinal damage occurs within a few hours after receiving doses of 300 rad or above. Inflammation in the damaged tissues leads to further complications, although it will be several days before the damage becomes apparent. By then, it is far too late to institute specific treatment. To be effective, treatment must be initiated within a few hours after exposure.

Intestinal fluid loss and electrolyte imbalance can be detected at an early stage. These changes are apparently responsible for the subsequent occurrence of diarrhea. Once the mechanism of injury has been identified, a specific treatment can be devised and given.

Level of Biological Organization	Important Radiation Effects
Molecular	Damage to enzymes, DNA etc. and interference to biological pathways
Subcellular	Damage to cell membranes, nucleus, chromosomes etc.
Cellular	Inhibition of cell division, cell death, transformation to a malignant state
Tissue, Organ	Disruption to central nervous system, bone marrow, intestinal tract. Induction of cancer
Whole Animal	Death; 'radiation life shortening'
Populations	Changes in the genetic characteristics of individual members

PROPHYLAXIS AND THERAPY

Prophylactic treatment is available, and should be given before an exposure to ionizing radiation to provide some degree of protection to vital tissues. For most agents currently available, toxicity and undesirable side effects are a real problem, and delivery of the agent is time-dependent. For example, optimal effects may be attainable only when the agent is administered 30 min before exposure.

For a radiation accident, prophylaxis is not possible unless the time of occurrence is known, or the protective effect can be prolonged. Once the mechanisms of damage to critical tissues, such as the bone marrow and intestine, are revealed, appropriate protective treatments can be devised.

Antioxidants are quite effective in scavenging free radicals produced by the passage of radiation through a cell, before they can interact with and damage critical macromolecules like DNA. There are combinations of different types of agents to reduce the toxicity of individual agents while maximizing the overall protective effect.

Therapeutic treatment delivered after exposure, depends upon the estimate of the dose received (from physical dosimetry) and most importantly on the accurate assessment of the actual damage sustained to critical tissues and organs (from biological dosimetry). Some of the new cytokine growth factors synthesized by recombinant DNA technology appear to be very effective in enhancing recovery of the bone marrow and immune systems. Some extra white blood cells are also produced to augment the defense against infectious organisms.

Sources

College of William and Mary, Chemistry Department
RMIT University, Department of Medical Radiations Science
NCRP Report No. 138

Links to external resources are provided as a public service and do not imply endorsement by the Washington State Department of Health.