# Radiation Sickness

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## Disease Overview

Summary



Radiation sickness describes the harmful effects–acute, dela
chronic–produced by exposure to ionizing radiation. An obse
due to radiation exposure becomes quite certain after a singl
several hundred rads. As a rule, large doses of radiation are of concern because of their immediate effects on the body (somatic), while low doses are of concern because of the potential for possible late somatic and long-term genetic effects. The effects of radiation exposure on an individual are cumulative.

Although there is currently no treatment to repair cells that have already been damaged by radiation, the FDA has recently approved drugs that are very effective at removing radioactive elements from the body. Because the damage is irreversible, patients exposed to radiation that are experiencing symptoms should seek medical help immediately so that drugs can be administered.

Introduction

The first observable cases of radiation sickness occurred after the nuclear bombing of Hiroshima and Nagasaki. Japanese doctors described an unknown disease with symptoms that "suddenly appeared in certain patients with no apparent injuries." It is now known that these first patients were suffering delayed effects of radiation exposure. Radiation sickness can result in patients with low exposure levels, such as cancer treatments, and leave them with symptoms similar to a case of the flu. However, in cases of extreme exposure caused from atomic weapons or a power plant meltdown, such as Chernobyl, the effects can be fatal.

Total dose and dose rate determine somatic or genetic effects of radiation. The units of measurement commonly used in determining radiation exposure or dose are the roentgen, the rad, and the rem. The roentgen (R) is a measure of quantity of x or gamma ionizing radiation in air. The radiation absorbed dose (rad) is the amount of energy absorbed in any substance from exposure, and applies to all types of radiation. The R and the rad are nearly equivalent in energy for practical purposes. The rem is used to correct for the observation that some types of radiation, such as neutrons, may produce more biological effect for an equivalent amount of absorbed energy; thus the rem is equal to the rad multiplied by a constant called the "quality factor". For x and gamma radiation the rem is equal to the rad. The rad and the rem are currently being replaced in the scientific nomenclature by two units that are compatible with the International System of Units, namely the gray (Gy), equal to 100 rads and the Sievert (Sv), equal to 100 rem.



## Synonyms

- Radiation Disease
- Radiation Effects
- Radiation Illness
- Radiation Injuries
- Radiation Reaction
- Radiation Syndrome

## Subdivisions

- acute radiation sickness

- delayed radiation sickness

## Signs & Symptoms

Acute radiation sickness is characterized by nausea, vomiting, diarrhea, anorexia, headache, malaise and rapid heartbeat (tachycardia). With mild ARS, the discomfort subsides within a few hours or days. However, there are three different types of severe ARS, which can develop as a result of high doses (e.g., an atomic explosion) to small doses (e.g., repeated x-rays over a period of days or weeks):

The type of severe ARS depends on dose, dose rate, affected area of the body, and the period of time elapsing after exposure. The severe ARS is due to penetrating radiation to most or all of the body in a short period of time, usually a few minutes. A patient with any type of severe ARS usually goes through three stages: In the prodromal stage, the classic symptoms are nausea, diarrhea and vomiting. This stage can last for a few minutes up to a few days. In the next stage, called the latent stage, a patient seems to improve to the point where they are generally healthy for a few hours or even a few weeks. The last stage, called the overt or manifest illness stage is specific to each type. They are cardiovascular/central nervous system sickness, gastrointestinal sickness, and hematopoietic sickness.

Cardiovascular/central nervous system sickness is the type o
produced by extremely high total body doses of radiation (gr
3000 rads). This type is the most severe and is always fatal. Ir
nausea and vomiting in the prodromal stage, patients with ce
syndrome will also experience anxiety, confusion, and loss of consciousness within a few hours, the latent period will occur. 5 or 6 hours after the initial radiation exposure, tremors, and convulsions will begin, and eventually coma and death are inevitable within 3 days.



Gastrointestinal sickness is the type of ARS that can occur when the total dose of radiation is lower but still high (400 or more rads). It is characterized by intractable nausea, vomiting, imbalance of electrolytes, and diarrhea that lead to severe dehydration, diminished plasma volume, vascular collapse, infection and life-threatening complications.

Hematopoietic sickness (bone marrow sickness)is the type of ARS occurs at exposure of between 200 to 1000 rads. Initially it is characterized by lack of appetite (anorexia), fever, malaise, nausea and vomiting, which

may be maximal within 6 to 12 hours after exposure. Symptoms then subside so that within 24 to 36 hours after exposure. During the latent period for this type, the lymph nodes, spleen and bone marrow begin to atrophy, leading to underproduction of all types of blood cells (pancytopenia). In the peripheral blood, lack of lymph cells (lymphopenia) commences immediately, reaching a peak within 24 to 36 hours. Lack of neutrophils, a type of white blood cell, develops more slowly. Lack of blood platelets (thrombocytopenia) may become prominent within 3 or 4 weeks. Increased susceptibility to infection develops due to a decrease in granulocytes and lymphocytes, impairment of antibody production and granulocyte migration, decreased ability to attack and kill bacteria, diminished resistance to diffusion in subcutaneous tissues, and bleeding (hemorrhagic) areas of the skin and bowel that encourage entrance and growth of bacteria. Hemorrhage occurs mainly due to the lack of blood platelets.

Delayed effects of radiation can lead to intermediate effects and late somatic and genetic effects. Intermediate effects from prolonged or repeated exposure to low radiation doses from a variety of sources may produce absence of menstruation (amenorrhea), decreased fertility in both sexes, decreased libido in the female, anemia, decreased white blood cells (leukopenia), decreased blood platelets (thrombocytopenia), skin redness (erythema), and cataracts. More severe or highly localized exposure causes loss of hair, skin atrophy and ulceration, thickening of the skin (keratosis), and vascular changes in the skin (telangie Ultimately it may cause a type of skin cancer called squamou carcinoma.



Kidney function changes include a decrease in renal plasma flow, glomerular filtration rate (GFR), and tubular function. Following a latent period of six months to one year after extremely high does of radiation, protein in the urine, kidney insufficiency, anemia and high blood pressure may develop. When cumulative kidney exposure is greater than 2000 rads in less than 5 weeks, kidney failure with diminished urine output may occur in about 37% of cases.

Large accumulated doses of radiation to muscles may result in painful myopathy with atrophy and calcification.

Inflammation of the sac around the heart (pericarditis) and of the heart muscle (myocarditis) have been produced by extensive radiotherapy of the middle region between the lungs (mediastinum).

Myelopathy may develop after a segment of the spinal cord has received cumulative doses of greater than 4000 rads. Following vigorous therapy of abdominal lymph nodes for seminoma, lymphoma, ovarian carcinoma, or chronic ulceration, fibrosis and perforation of the bowel may develop.

Late somatic and genetic effects of radiation can alter the genes in proliferating cells of the body and germ cells. With body cells this may be manifested ultimately as somatic disease such as cancer (leukemia, thyroid, skin, bone), or cataracts. Another type of cancer, osteosarcoma, may appear years after swallowing radioactive bone-seeking nuclides such as radium salts. Injury to exposed organs may occur occasionally after extensive radiation therapy for treatment of cancer.

When cells are exposed to radiation, the number of mutations is increased. If mutations are passed down to children, this can cause genetic defects in the offspring.

## Causes

Harmful sources of ionizing radiation are limited primarily to high-energy x-rays used for diagnosis and therapy, and to radium and related radioactive materials. Present sources of potential radiation include nuclear reactors, cyclotrons, linear accelerators, alternating gradient synchrotons, and sealed cobalt and cesium sources for cancer therapy. Numerous artificial radioactive materials have been produce medicine and industry by neutron activation in reactors.



The accidental escape of moderate to large amounts of radia reactors has occurred several times. The radiation from the atomic bombs dropped in Hiroshima and Nagasaki caused hundred of cases of cancer, mutations, and genetic defects years after the explosion. Radiation exposure from reactor accidents like Chernobyl, for example, resulted in 134 illnesses and 28 deaths.

Very low doses of radiation such as unavoidable background radiation (about 0.1 rad/yr), produce no measureable effect. Mild symptoms have been observed with doses as low as 30 rad. The probability of measurable effects increases as the dose rate and/or total dose increases.

The area of the body exposed to radiation is also an important factor. The entire human body can probably absorb up to 200 rads acutely without fatality. However, as the whole-body dose approaches 450 rads the death

rate will approximate 50%, and a total whole-body dose of greater than 600 rads received in a very short time will almost certainly be fatal. By contrast, many thousands of rads delivered over a long period of time (e.g. for cancer treatment), can be tolerated by the body when small volumes of tissue are irradiated. Distribution of the dose within the body is also important. For example, protection of bowel or bone marrow by appropriate shielding will permit survival of the exposed individual from what would be an otherwise fatal whole-body dose.

## Affected populations

Radiation sickness can affect males and females in equal numbers.

## Diagnosis

Diagnosis is typically made based on a history of significant radiation exposure. The time between exposure and vomiting also can give good estimates of exposure levels in a patient.

Clinical Testing and Work-Up

Monitoring of exposed patients is mandatory, using Geiger counters or sophisticated whole-body counters. Urine should be analyzed for non-gamma-emitting radionuclides if exposure to these agents is suspected. Radon breath analysis can be done in cases of suspected radi ingestion.



## Standard Therapies

**Treatment**

Contamination of the skin by radioactive materials should be immediately removed by copious rinsing with water and special solutions containing an agent such as EDTA (ethylenediamine tetraacetic acid), a chelating agent which binds many radioactive isotopes. Small puncture wounds must be cleaned vigorously to remove contamination. Rinsing and removal of contaminated tissue are necessary until the wound is free of radioactivity. Ingested material should be removed promptly by induced vomiting or by washing out the stomach if exposure is recent.

If radioiodine is inhaled or ingested in large quantities, the patient should be given potassium iodide to block thyroid uptake for days to weeks, and diuresis should be promoted.

In 2015, Neupogen (filgrastim) was approved to treat adult and pediatric patients acutely exposed to myelosuppressive doses of radiation (hematopoietic syndrome of acute radiation syndrome, or radiation sickness). Neupogen is manufactured by Amgen, Inc.

Prussian blue is a pigment that has been used in industry for centuries and has also been approved by the FDA for the treatment of radioactive cesium and non-radioactive thallium exposure. Prussian blue traps these elements in the intestine so that they can be passed out of the body as stool instead of being absorbed.

Ca-DTPA and Zn-DTPA are also FDA approved drugs that speed up the excretion of elements such as plutonium, americium, and curium from the body. Ca-DTPA is given as a first dose, as it is more effective, but after the initial 24 hours, both are equally effective and Zn-DTPA becomes preferable because it removes less essential metals, such as zinc.

For the cardiovascular/central nervous system sickness, treatment is symptomatic and supportive. It is aimed at combating shock and lack of oxygen, relieving pain and anxiety and sedation for control of convulsions.



If the gastro-intestinal sickness develops after external who irradiation, the type and degree of therapy will be dictated b severity of the symptoms. After modest exposure, antiemeti sedation may suffice. If oral feeding can be started, a bland diet is tolerated best. Fluid, electrolytes, and plasma may be required in huge volumes. The amount and type will be dictated by blood chemical studies (especially electrolytes and proteins), blood pressure, pulse, urine output, and skin turgor.

Management of the hematopoietic sickness, with its obvious potentially lethal factors of infection, hemorrhage and anemia, is similar to treatment of marrow hypoplasia and pancytopenia from any cause. Antibiotics, fresh blood, and platelet transfusions are the main therapeutic aids. However, a side effect of platelet transfusions may be development of an immune response to future platelet transfusions. Rigid germ-free conditions (asepsis) during all skin-puncturing procedures is mandatory as is strict isolation to prevent exposure to

disease-causing germs.

Concurrent anticancer chemotherapy or use of other marrow-suppressing drugs, should be avoided.

Radiation ulcers and cancers require surgical removal and plastic repair. Radiation-induced leukemia is treated like any similar spontaneously occurring leukemia. Anemia is corrected by blood transfusion. Bleeding due to lack of platelets (thrombocytopenia) may be reduced by platelet transfusions.

No effective treatment for sterility, or for ovarian and testicular dysfunction (except for hormone supplementation in some cases), is currently available.

## Clinical Trials and Studies

Bone marrow transplants have proven helpful in some cases. If a whole body radiation dose greater than 200 rads is suspected, and if granulocytes and platelets continue to decrease and fall to less than 500 and 20,000/ cu mm, respectively, compatible bone marrow transplantation should be made. With use of cyclosporin to prevent rejection of the graft, a marrow transplant will most likely increase the probability of survival. Thirteen people at Chernobyl who received estimated total body doses of radiation between 5.6 to 13.4, underwent bone marrow transplants after the Chernobyl accident. Two recipients survived. Others died of various causes including l vs-host disease, kidney failure, etc. Therefore, the success of marrow transplantation for radiation sickness was inconclus



Information on current clinical trials is posted on the Internet at www.clinicaltrials.gov. All studies receiving U.S. government funding, and some supported by private industry, are posted on this government web site.

For information about clinical trials being conducted at the NIH Clinical Center in Bethesda, MD, contact the NIH Patient Recruitment Office:

Tollfree: (800) 411-1222

TTY: (866) 411-1010

Email: prpl@cc.nih.gov

For information about clinical trials sponsored by private sources, contact:

www.centerwatch.com

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# Programs & Resources

## RareCare® Assistance Programs

NORD strives to open new assistance programs as funding allows. If we don't have a program for you now, please continue to check back with us.

## Additional Assistance Programs

### MedicAlert Assistance Program

NORD and MedicAlert Foundation have teamed up on a new program to provide protection to rare disease patients in emergency situations.
https://rarediseases.org/patient-assistance-programs/medicalert-assistance-program/

### Rare Disease Educational Support Program

Ensuring that patients and caregivers are armed with the tools they need to live their best lives while managing their rare condition is a vital part of NORD's mission.
https://rarediseases.org/patient-assistance-programs/rare-disease-educational-support/

### Rare Caregiver Respite Program

This first-of-its-kind assistance program is designed for caregivers of a child or adult diagnosed with a rare disorder.
https://rarediseases.org/patient-assistance-programs/caregiver-respite/



## Patient Organizations

### Rare Cancer Alliance
https://rarediseases.org/non-member-patient/rare-cancer-alliance/

### American Cancer Society, Inc.

Phone: 404-320-3333

https://rarediseases.org/non-member-patient/american-cancer-society-inc/

### Leukemia & Lymphoma Society

Phone: 914-949-5213 Email: infocenter@LLS.org

Fax: 914-949-6691

https://rarediseases.org/non-member-patient/leukemia-lymphoma-society/