

Acute Radiation Syndrome

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People everywhere are exposed to radiation daily. In general, most humans on the planet are exposed to 1 to 2 milliGray (mGy) a year.(1) This is referred to as “background radiation.” Radiation is present all around us: in the air, in the ground and in the water. Some of the most common forms of radiation that people are exposed to may come from natural sources such as cosmic rays and substances in the earth’s crust, such as Radon.(1) Other exposures come from man made substances such as waste from nuclear reactors, diagnostic machines such as x-ray, CAT-scan or mammogram machines and the use of radioactivity in cancer treatment. There are, however, more serious types of radiation exposures, such as nuclear accidents and atomic weapons use and testing. These persons who are affected by a single exposure of high levels of ionizing radiation and become very ill are said to have acute radiation syndrome (ARS). As ionizing radiation passes through the body the interaction with tissues causes the transfer of ionizing energy to critical cell systems.(2) In this paper discussion will deal with the causes, symptoms and possible treatments of each of the syndromes associated with ARS. All of the syndromes will be discussed but primary focus will be on the Gastrointestinal Syndrome.

ARS is technically known as the symptoms observed within a few months following high level radiation exposure.(3) ARS comes from a single whole body exposure of high levels of ionizing radiation. The exposure needed to constitute ARS is between 2 Gy and 100 Gy.(4) There are three syndromes associated with

ARS: Cerebrovascular Syndrome, Gastrointestinal Syndrome and the Hematopoietic Syndrome. These syndromes vary in the expressed symptoms and the amount of dose that is required to cause them. When viewed alone these symptoms are not specific to ARS but when viewed collectively they are considered characteristic.(5) Each of these syndromes can be divided into three phases: the prodromal phase, the latent phase and the manifest illness.(5) These phases each have different symptoms associated with them depending on the syndrome being discussed.

Cerebrovascular Syndrome also known as Neuromuscular Syndrome requires the highest dose of radiation, on the magnitude of greater than 100 Gy.(4) This syndrome is the least understood and is referred to as a physiological death because the symptoms and ultimate death appear so quickly. All organ systems are severely damaged at this dose but the damage to the cerebrovascular system is quite severe and usually causes death within 2 days.(5) The prodromal phase of this illness occurs within minutes of exposure, causing severe nausea, abdominal cramping, headache and vomiting. This leads to disorientation and loss of muscular coordination. The latent phase of this illness is very short because of the severity of injury, however, there is usually a point at which the patient claims to feel a bit more comfortable. This feeling lasts a short time and leads directly into the next phase. During the manifest illness the nausea, cramping, headache, vomiting and disorientation continue until the patient starts to exhibit convulsive seizures, which lead to coma and

eventually death. This syndrome is not very well understood because of the lack of persons who have been exposed to the high doses the syndrome requires to manifest itself.

The syndrome requiring the lowest dose of radiation is the Hematopoietic Syndrome. This syndrome requires a dose on the magnitude of 2-8 Gy.(4) This syndrome with proper treatment does not always cause death. The understanding of the Hematopoietic Syndrome comes from the knowledge of cancer treatments. Patients who are about to receive a bone marrow transplant are given whole body irradiation of these dose levels, although generally given in fractionated doses. The stem cells in the body are the most radiosensitive cells, which is why such a small dose causes damage. This syndrome is referred to as reproductive death since the body does not show effect until the stem cells attempt division and are unable to do so. Symptom onset generally occurs within a week and may last up to six weeks.(7) This is the time it will take the stem cells to reach a critical level. The prodromal phase of this illness causes nausea and vomiting that present shortly after irradiation. The latent phase of this syndrome is generally symptom free, this is the time when the prodromal symptoms subside and the real cellular damage begins. This phase will start anytime after exposure and can last up to three weeks. During the latent phase the cells have attempted to repair the damage. The patient then enters the manifest illness. With this phase the patient begins to have chills, becomes fatigued, skin hemorrhages are formed and ulcers are formed in the mouth.

These symptoms are all manifestations of the depletion of the stem cells.(4) Infections and fevers will also persist and demonstrate an impairment of the immune system.(4) Patients with the syndrome respond reasonably well to treatment if it is started early enough. If the patient is given high doses of antibiotics to ward off infection, plenty of fluids to prevent dehydration and given a bone marrow transplant to replace the stem cells lost with irradiation the patient has a chance of survival.

The final and most interesting syndrome is the Gastrointestinal Syndrome. This syndrome requires a dose of more than 8 Gy.(4) Although the higher dose is serious and causes some cell death immediately after exposure due to apoptosis, the Gastrointestinal Syndrome is also considered reproductive death, because of the effect of the radiation on the mucousal lining of the intestines.(6) These mucosa are made up of villi, which protrude from the lining of the intestine and create more surface area for absorption of nutrients. This syndrome can last from 3 days to many weeks. Survival from this syndrome is rare.

The prodromal phase of this syndrome starts immediately after exposure with symptoms of vomiting, upset stomach, nausea, diarrhea, loss of appetite and decreased blood pressure. Toward the end of this phase the mucosa of the nasal and esophageal passages start to dry out, become swollen and ulcerated leading to difficulty in swallowing and causing dry mouth with a metallic taste.(2) These symptoms will last about 3 to 5 days.(4) This passage

begins the latent phase which is generally asymptomatic. This phase is similar to the latent phase of the Hematopoietic Syndrome, meaning the time between irradiation and the expression of the cell damage. The length of the latent phase can be correlated to the dose received. Manifest illness begins with the increase of dehydration, diarrhea and abdominal pain. These symptoms are due to trauma of the intestinal villi, which consist of four regions.(7) The crypt stem cells, which normally divide with high mitotic activity. The differentiating compartment which is a region farther up the villus where cells are differentiated into functional cells. These differentiated cells migrate to the near tip of the villus, where the most absorption takes place. These cells will replace the functional cells at the tip of the villus. The very top of the villus is where the functional absorption cells are located and are sloughed off the villi with the passing of the intestinal contents. In an unirradiated system the crypt cells would repopulate these functional cells as fast as they were being lost.(7) The irradiation suffered in this syndrome causes the crypt cells to perish and they are unable to create new functional cells to replace the discarded ones. This causes the denudation of the intestine. Cells of the stomach, colon and rectum are soon depleted as well. These occurrences cause the increased dehydration and diarrhea. After the intestinal breakdown, bacteria are able to enter the bloodstream through the denuded intestine and cause serious infection because of the destruction of the stem cells in the blood, which we saw earlier is the Hematopoietic Syndrome. This causes fever and septicemia in the patient.(5)

Although survival of the Gastrointestinal Syndrome is rare there is a possibility of rescuing a patient when the exposure is less than 10 Gy. Survival would only occur if the intestinal stem cells were not completely destroyed. If the intestinal crypt cells are able to repopulate themselves then proper treatment may help some patients. This requires high levels of antibiotics to control infection and a constant supply of fluids to help with the dehydration. A bone marrow transplant would be needed as well. The treatment of Gastrointestinal Syndrome also requires the treatment of Hematopoietic Syndrome. There is no exact data given on survival of Gastrointestinal Syndrome because so few people have been exposed to these levels. There have not been any reported cases of survival for patients with exposures over 10 Gy.(5)

In cases of total body irradiation with high levels of exposure the likelihood of survival is low and the symptoms of these syndromes are plentiful. Fortunately there are very few instances where people have been exposed to such high levels of radiation. By ensuring safety at nuclear reactors and reducing the quantity of nuclear weapons use and testing the exposures to these levels of radiation will hopefully become unheard of.

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