National Marrow Donor Program®

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

The National Marrow Donor Program (NMDP) and the U.S. Navy has developed a contingency plan to respond to radiation incidents in which stem cell transplantation may play a role in the treatment of casualties. This fact sheet is an introduction to radiation incidents and to some of the medical issues involved in treating radiation victims with stem cell transplantation.

A radiation incident is any occurrence, whether deliberate or accidental, which results in irradiated victims. A radiation incident could be military in origin (nuclear war, accidents involving military nuclear materials), an act of terrorism, or the result of an accident at a nuclear reactor or fuel-processing facility. In any event, casualties from a radiation incident may be military personnel, civilians, or both.

What is radiation?

Radiation is high-energy electromagnetic waves (x-rays, gamma rays) or high-energy particles (alpha or beta particles) that result from nuclear transformations. Nuclear transformations can be very rapid and violent, such as a nuclear explosion, or slow and steady, such as 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 continues until all the radiation energy is released in a short burst. The 1986 accident at Chernobyl was a criticality accident, as was the 1999 accident at a nuclear processing facility in Japan.

Because radiation disrupts cellular reproduction, whenever individuals come in contact with radiation, their chances of developing cancer increase. Incidental exposures, especially minor exposures spread out over time, increase cancer risk only slightly. Larger exposures lead to larger increases in cancer risk. However, when large doses of radiation are received in a short period of time, acute radiation syndrome (ARS) occurs, which involves hematological abnormalities and damage to the body's internal organs. Because a portion of ARS victims may be helped by stem cell transplantation, the NMDP and the U.S. Navy have developed a contingency plan that utilizes the NMDP network to respond to several different types of radiation incidents.

Acute radiation syndrome

Typical treatment for acute radiation syndrome patients includes general supportive care, topical and systemic antibiotics, and treatment for any radiation-induced burns. ARS develops in three stages: initial (or prodromal), latent, and manifest illness. The initial stage lasts 1-2 days, during which the victim may experience nausea, anorexia, vomiting, and diarrhea. Physicians can get an estimate of radiation dose by noting the duration of time between exposure and the onset of these initial symptoms. The sooner these symptoms appear, the greater the radiation dose received.

Following the initial stage, the ARS patient enters a latent stage in which there are few outward symptoms, but it is during this time that marrow and blood cell counts may begin to decline. Because bone marrow is the most radiation-sensitive tissue or organ in the body, physicians can also monitor a victim's blood and marrow cell counts to estimate the severity of a radiation exposure. The duration of the latent stage depends upon the radiation dose, with high-exposure

patients quickly progressing from the latent stage to the manifest illness stage. In low-exposure cases, the latent period may last for several weeks.

In the manifest illness stage, the marrow and blood cell counts are severely depressed and the patient may also develop gastrointestinal bleeding and decreased functioning of the lungs, liver, brain, and skin. If these organs are severely damaged, the patient is at high risk for infection.

Stem cell transplantation after a radiation incident

In a radiation incident with multiple victims receiving a range of exposures, a portion of the highly irradiated victims will die soon after exposure from their radiation injuries, and a portion will die later on. The causes of death vary, but they include infection, hemorrhage, organ failure, and burns. In addition, a portion of the victims receiving very mild doses of radiation will spontaneously recover soon after being exposed. Other victims receiving a slightly higher exposure may recover later on, after receiving supportive care, burn treatment, decontamination and/or detoxification.

Finally, there may be a portion of radiation victims who fall into none of these categories. These victims will have absorbed enough radiation to experience major bone marrow trauma, and they will be unable to recover hematological function without extensive treatment -- treatment that may include stem cell transplantation. From studying the experiences of radiation victims from incidents such as the Chernobyl accident, physicians and radiation experts have estimated that individuals receiving 3-5 Gy of radiation in a single dose are most likely to be helped by stem cell transplantation.[*] (Because of the inherent difficulty in determining a precise level of exposure following a radiation incident, these figures are estimates only.)

The role of the NMDP

The NMDP, in conjunction with the U.S. Navy, has developed a contingency plan to prepare for radiation incidents that may produce victims who are unlikely to recover hematopoiesis by themselves. However, some victims within this range of radiation exposure may also have physical trauma, respiratory distress, burns, and/or infections that could exclude them from receiving a stem cell transplant. The NMDP/Navy has therefore developed treatment protocols that establish clear guidelines for managing various types of casualties that may result from a radiation incident.

A detailed description of these treatment protocols is beyond the scope of this fact sheet, so only a summary is presented here. The treatment protocols contain the following clinical criteria regarding the treatment of radiation casualties:

- Treatment protocols for pre- and post-transplant care must take into account the specific clinical conditions associated with radiation victims, i.e., burns, infections and organ damage.

[*] The Gray (abbreviated Gy) is a measure of the absorbed dose of radiation. 1 Gy = 100 rads = 1 joule (a measurement of energy) per kilogram of body weight.

- Radiation victims with severe burns and/or radiation damage to organs should not be transplanted.
- Administering growth factors (GM-CSF, interleukin-3) may also be appropriate treatment for some ARS patients with bone marrow failure.
- Because cord blood grafts typically take longer to engraft than marrow or PBSC grafts, cord blood should not usually be the preferred source of stem cells for treating ARS patients.
- The timeline for managing ARS victims is roughly 3-4 weeks. The decision whether to transplant must therefore be made soon as possible after exposure to allow sufficient time to locate a suitable stem cell donor.
- To expedite the donor search process, the contingency plan utilize existing facilities and personnel within the NMDP network whenever possible.

For more detailed discussions of the clinical manifestations of radiation injuries and the clinical issues concerning the treatment of radiation victims, refer to the following sources:

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