Biological Effects of Ionizing Radiation: a Perspective for Japan

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Most of the world press assumes that all radiation is harmful. If the Japanese government acts on this presumption in responding to the nuclear reactor damage from the March 2011 earthquake and tsunami at Fukushima, Japan's already reeling economy will be crushed by tremendous unwarranted expense. Japan should learn from Chernobyl what Mikhail Gorbachev understood too late: "The nuclear meltdown at Chernobyl 20 years ago…was perhaps the real cause of the collapse of the Soviet Union five years later."[1]

Ionizing radiation is hormetic. The concept of hormesis, which is not generally understood by news media and governments, is that small doses are beneficial, while large doses are harmful. This effect is known to occur for about 40 essential nutrients, all drugs, and most other agents. Both chronic and acute exposures to ionizing radiation exhibit hormesis. Consideration of the full spectrum, beneficial as well as harmful, of the biological effects of ionizing radiation is vital to understanding the importance of nuclear fallout.

There are thousands of scientific papers showing benefit from low doses of ionizing radiation.[2,3,4] Japan could consult its own world renowned scientist, Dr. Sadao Hattori,[5] retired director of research for the Central Research Institute of Electric Power Industry of Japan. Instead, there is a tendency to rely on the Radiation Effects Research Committee (RERF) in Hiroshima, which spends millions of dollars searching for the harm from ionizing radiation, and is not a reliable source of information about the health benefits from ionizing radiation.

Ionizing Radiation Is Essential for Life

Experiments with appropriate shielding in brine shrimp,[6] protozoa,[7,8] and mice and rats[9] have produced convincing evidence that ionizing radiation is essential for life. In Luckey's study of protozoa and Kuzin's of mice and rats, researchers replaced natural (radioactive) potassium with the non-radioactive potassium-39 to produce radiation deficiency. These reports suggest that ionizing radiation is also an essential agent for humans.

The concept that we live with a radiation deficiency is supported by more than 2,000 scientific papers showing that low-dose irradiation stimulates the well being of laboratory animals and humans.[3, 4] The data indicate that ambient levels of ionizing radiation throughout the world, 3 mSv/y,[10, p 198] are insufficient for vibrant health. For example, evidence suggests that if we received adequate ionizing radiation, cancer would be a rare disease .

Chronic Exposure

A complete dose-response curve (Figure 1) shows the optimum ionizing radiation rate associated with the minimal cancer death rate and maximal life span: about 100 mGy/y.[11] The zero equivalent point (ZEP), the rate that divides healthful from harmful effects, is about 10,000 mGy/y. Exposure rates greater than ZEP may produce symptoms of radiation sickness and death.

Evidence for this concept comes from Taipei.[12] In 1982-1984, radioactive cobalt-contaminated steel was used for girders in an apartment complex. During the next two decades about 10,000 people lived in this enriched radioactive environment. The average dose received was 50 mSv/y. This dose is close to the optimum dose of 100 mSv/y. (Sv and Gy are about equal in the new evaluation.)[13] The cancer death rate for these apartment

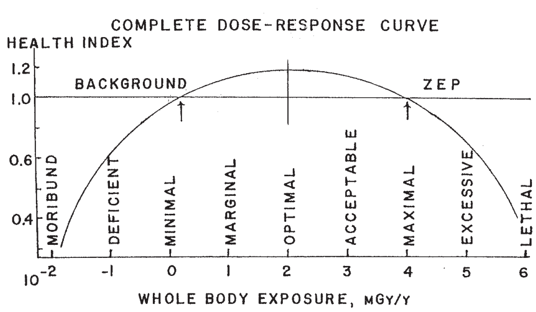

Figure 1. A Spectrum of the Effects of Ionizing Radiation. The complete dose-response curve for ionizing radiation includes radiation deficiency, radiation optimum, and radiation toxicity (modified from Luckey 1991,[3] Figure 9.3, p 230). The ordinate indicates a relative index of health. The abscissa provides the power of the exposure with the base of 10. The background is about 3 mGy/y and the zero equivalent point (ZEP) is about 10 Gy/y.

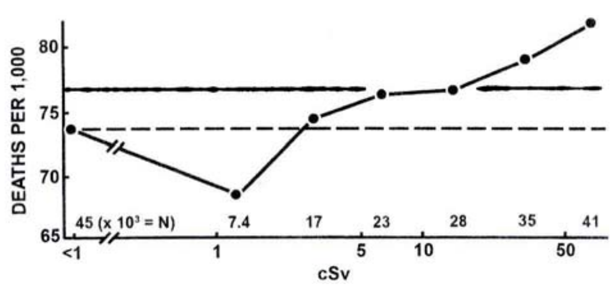

Figure 2. Cumulative Cancer Mortality Rates. Cancer mortality rates per 1,000 survivors of Hiroshima and Nagasaki are displayed for estimated radiation exposure. Numbers above the abscissa indicate thousands of people included in each point; i.e. the number receiving a dose ≤ *x*. The dashed horizontal line represents the RERF "in-the-city control," 3-10 km from ground zero. The mortality rate for those exposed to about 1 cSv is significantly less than that for the RERF control (*P*<.01). The solid line represents the cancer mortality rate of people in villages northwest of Hiroshima.

dwellers was only 3.5 per 100,000 person years; 116 deaths per 1,000 person years were anticipated from consideration of controls. Although thorough studies have not been made, it appears that chronic low-dose irradiation decreases cancer mortality rates. Lung cancer mortality rates as a function of indoor radon concentrations in the U.S. support this view.[14]

Acute Exposure

Conclusions about the effects of acute exposure are generally based on data on the Japanese survivors of the atomic bombs (see Figure 2).[15] The RERF compared the cancer mortality of Hiroshima and Nagasaki survivors with that of people who were 3-10 km from ground zero ("in-the-city controls"). These controls received some radiation from the bombs, and many went into the bombed areas while residual radiation was high. Total [all-cause] "mortality rates in 120,321 atomic bomb survivors were not increased at doses <490mSv."[16, p46]

The cancer mortality rate of the 7,430 survivors of Hiroshima and Nagasaki who received 10-19 mSv was 68.5% (P<.01) of that of controls.[17] The 28,423 survivors (69% of all survivors) who received <200 mSv had 76.6 cancer deaths per 1,000 people (see Figure 2). This was close to the value, 77 cancer deaths per 1,000 people, found for the unexposed people in villages northwest of Hiroshima.[18] Note that this "out of city" control population had more cancer deaths per 1,000 people than the RERF "in the city" control cohort, a comparison that RERF never makes.

Exposures greater than 200 mSv showed increased cancer death rates commensurate with increasing dose. Thus the ZEP for acute ionizing radiation was about 200 mSv. Radiation sickness was caused by exposures >2,000 mSv.

More evidence comes from 23 young Japanese fishermen who received fallout from the explosion of a hydrogen bomb at Bikini Island in March 1954. All suffered severe radiation sickness. Whole body doses were 170-590 cSv (1,700–5,900 mSv), according to Eisenbud's Table 12.1.[10] Thyroids received 300-1,000 cSv. The man who received the largest dose died 206 days following exposure. The others survived for more than two decades with no cancers.

Triage for Radiation

The above information provides a tentative guide for the treatment of people exposed to different amounts of chronic and/or acute ionizing radiation. Triage following a nuclear accident or explosion provides the most good for the most people. Triage for people with acute radiation exposures usually involves consideration of other problems also, such as psychological reactions, physical disabilities, injuries from flying debris, and/or inadequate food, water, and housing.

The major concern here is trauma caused by direct irradiation; this contributes about 5% of the total harm from atomic bombs.[19] Triage also includes radiation from many external and internal radionuclides; this accounts for about 10% of the total harm from a nuclear explosion. Blast and heat cause about 80% of the total harm. These guidelines are of limited value in nuclear accidents.

Radiation triage is relatively simple for people with chronic exposures from external sources. People exposed to less than 10 Gy/y (about 1 mGy/h) from external radiation can immediately help those less fortunate. People exposed to 2-10 mGy/h for prolonged periods should be placed under observation. Reddening of the skin (as in sunburn) is symptomatic of minor excess radiation. People exposed to 11-100 mGy/h for an extended time will have radiation sickness and should be placed under medical care. People who receive more than 1 Gy/h will have serious radiation sickness. People exposed to more than 10 Gy/h should be placed in a hospice with care and a blessing.

The combined data from Hiroshima and Nagasaki[17] indicate that people exposed to less than 1,000 mSv acute radiation should be recruited to help those who are disabled and sick. People exposed to 1,000-2,000 mSv acute radiation may require treatment for radiation sickness. People exposed to 2,000-6,000 mSv need immediate hospitalization. People with more than 6,000 mSv should be placed in a hospice with care and a blessing. The quality factor (Q) of nuclear explosions needs to be re-examined.[13]

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