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The Contribution of Medical Physicists to Radiation Phobia

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THE CONTRIBUTIONS OF MEDICAL PHYSICISTS TO RADIATION PHOBIA

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This title is deliberately provocative. However it can be broadened to refer not only to medical physicists but also to the great majority of scientists who should be knowledgeable about the biologic effects of low level radiation, but who have not been actively engaged in educating the public and politicians about these effects. Most of us accept that there is a fringe group of scientists whose public pronouncements and appearances at so-called radiation injury trials are outrageous. When Senator Metzenbaum enters into the Congressional Record (S-8760: June 26, 1986) a prediction by John Gofman that there would be 9000 leukemia deaths in Finland as a consequence of the fallout from Chernobyl, official credence is certainly given to the fallacious pseudo-science of this fringe group. Such a prediction is obviously inconsistent with an increase through 1978 of only 90 leukemia deaths among the 80,000 survivors of the Hiroshima-Nagasaki bombing. Through our organizations and as individuals we should be better organized to combat such misinformation that is so pervasive throughout the media and which influences public beliefs and legislative action.

My more fundamental concern arises from the damage done by our accepting and even promoting the person-rem concept as the scientifically credible basis for predicting radiation-related malignancies. Implicit in the acceptance of this concept is the validity of the linear extrapolation hypothesis - which implies

that there is no dose-rate effect for injury from low LET radiation and no threshold for radiation-induced carcinogenesis. In place of use of the person-rem concept, consideration should be given to expressing doses in rem/person and comparing occupational or other man-made exposures to the 3 rem per 30 year acquired from exposure to cosmic, terrestrial and internal ^{40}K radiation or the 10 rem/person if the NCRP Report 93 calculation including radon were valid.

Let us consider first what we know about the importance of dose-rate effects in radiation-induced malignancy for any given cumulative dose. It is important in such studies to distinguish between fractionated doses administered at high dose-rates and continuous irradiation at low dose-rates. There have been numerous animal studies demonstrating that the incidences both of leukemias and of solid tumors are markedly reduced when doses in the 100-300 rad range are delivered in days instead of in minutes. The relevant human evidence depends in part on the past use of ^{131}I for diagnosis of thyroid disease and for the treatment of hyperthyroidism. Although only a small fraction of the more than 1 million patients who had ^{131}I-uptake studies 20 or more years ago and received 50-100 rem thyroidal doses have been studied, no increase in thyroid cancer has been observed in this group. If risk factors based on studies of external radiation at high dose rates were applied to this group, a 5-fold or greater thyroid cancer incidence would have been expected. Similarly, the absence of an increased incidence of leukemia following ^{131}I-treatment of

hyperthyroidism, which generally delivers about 10 rem of generalized body radiation, is also consistent with a risk factor no more than 1/5 as great for radiation delivered over a period of days rather than seconds. Perhaps the most critical evidence will become available in a very few years from observations on the evacuees following the Chernobyl accident. A group of about 25,000 people living between 3 and 15 km. from the reactor were reported to have had an average dose of about 50 rem, which is quite comparable to the doses received by the survivors of the Hiroshima-Nagasaki bombings -- but at a considerably lower dose-rate. Will these survivors experience the same degree of leukemogenesis? We should soon know the answer since there was a doubling of leukemia incidence in the Japanese survivors during the 5-10 year period after the bombing.

With the new Hiroshima-Nagasaki dosimetry there is a movement underway to reduce the NCRP and ICRP dose limits for occupational exposure below the current level of 5 rem per year. It would probably not be difficult or even expensive to comply with recommendations for setting lower limits. After all, according to the BEIR III report, in 1975 96.5% of hospital-based radiation workers and 90% of industrial workers, including those working in reactor power plants or processing nuclear fuels, received less than 1 rem. Almost half of both groups received no measurable radiation. Nonetheless to lower the limits would suggest that there is some observable inherent risk at the current level and would raise great concern among radiation workers.

The picture of Marie Curie stirring large vats during the purification of radium will never of course be seen again. There is no doubt that early radiation workers had an increased incidence of aplastic anemia, leukemia and bone cancer. As a result by the 1920's radiation standards were initiated. What do we know about the extent of harmful effects among radiation workers exposed since the 1920's? A report in 1981 of the mortality from cancer and other causes among 1338 British radiologists who joined radiologic societies between 1897 and 1954 revealed that in those who entered the profession before 1921, the cancer death rate was 75% higher than that of other physicians. However those entering radiology after 1921 had cancer death rates quite comparable to those of other professionals. Although the exposures of the radiologists were not measured, estimates suggest that those who entered the profession between 1920 and 1945 could have received accumulated whole-body doses during their working years as large as 100 to 500 rem.

Another large group of radiation workers who have been studied were men in the Armed Services trained as radiology technicians during World War II and who subsequently served in that capacity for a median period of 24 months. Description of their daily training included the statement that "During the remaining two hours of this period the students occupy themselves by taking radiographs of each other in the positions taught them that day". This report noted that the students did not receive a skin erythema dose nor did they show a drop in white count, monitoring procedures

which are insensitive to acute doses less than 100 rem. From what we now know, these technicians probably received at least 50 rem or more during their training and several years of service. Yet a 29-year follow-up of these 6500 radiology technicians revealed no increase in malignancies when compared with a control group of similar size consisting of Armed Services medical, laboratory, or pharmacy technicians.

Studies such as these suggest that the current maximum permissible dose levels could not be measurably deleterious. However to lower the limits suggests that the existing values are potentially harmful and contributes to radiation phobia in the general population.

In 1981 a Government Accounting Office Report on Cancer Risks of Low-Level Ionizing Radiation concluded that "there is as yet no way to determine precisely the cancer risks of low-level ionizing radiation exposure, and it is unlikely that this question will be resolved soon." The question as to whether there exists a threshold below which radiation effects in man do not occur should continue to be addressed. One can develop a tenable model that would be consistent with such a threshold. Since human beings are more than 75% water, low-LET ionizing radiation is largely absorbed in the water resulting in the production of free radicals. Thus, many of the potential biochemical changes initiated in the cell and, in particular, damage to cellular DNA are probably a consequence of the indirect action of the products of water radiolysis. If molecules which scavenge radicals and which are

normally present in tissue greatly exceed in concentration the free radicals generated at low dose-rates, there may well be no initiating event, i.e., damage to DNA. The threshold could be the dose-rate at which the radiation-induced free radicals exceed the scavengers. It is likely to be dependent on the animal species and the specific tissue of concern. Such a hypothesis is consistent with the marked dose-rate effects observed in animal studies and is independent of other factors such as repair mechanisms that may also be operative to diminish damage.

The NCRP Report 43 dealing with Radiation Protection Philosophy stated unequivocally in 1975 that "The indications of a significant dose-rate influence on radiation effects would make completely inappropriate the current practice of summing of doses at all levels of dose and dose-rate in the form of total person-rem for purposes of calculating risks to the population on the basis of extrapolation of risk estimates derived from data at high doses and dose-rates...". As Medical Physicists we should not only remember this statement but we should become actively involved in promoting this message to governmental agencies and to the society in which we live. If we fail to do so we are contributing to the radiation phobia which is based on the concept that any amount of ionizing radiation delivered at any rate is hazardous to human health. Such fears impact on the beneficial role of radiation in diagnosis and therapy, nuclear medicine and nuclear power.