

LETTERS TO THE EDITOR

Description of the Chronic Radiation Syndrome in Humans Irradiated in the Former Soviet Union

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The purpose of this letter is to call attention to the availability of a technical report on the chronic radiation syndrome (CRS) which may be obtained from the Armed Forces Radiobiology Research Institute (AFRRI). Pursuant to facilitating communications between radiation scientists in the United States and the former Soviet Union, AFRRI and the Defense Nuclear Agency (DNA) have provided small amounts of funding for scientists in the former Soviet Union to conduct pilot experiments or to pursue critical archiving documentation and/or analysis of existing data. The overarching goal was to augment the process whereby important newly available data or ideas could be communicated outside the former Soviet Union for evaluation by the scientific community. One such effort is a report entitled *Analysis of Chronic Radiation Sickness Cases in the Population of the Southern Urals*, authored by M. M. Kossenko, A. A. Akleyev, M. O. Degteva, V. P. Kozheurov and R. G. Degtyaryova, that describes CRS, a syndrome considered by the authors to be unique.

After World War II the Soviet Union rapidly accelerated its nuclear weapons program. Plants for processing fuel for weapons were quickly set up, the first one near the city of Chelyabinsk in the Southern Urals. Because of the perceived urgency for rapid production of nuclear weapons, some compromises seem to have been made. Authorities felt that release of radioactive wastes below a certain concentration did not pose a significant hazard to the health of the villagers downstream along the Techa River from the "Mayak" plant. Accordingly, between 1950 and 1951 an average of 4,300 Ci were discharged daily into the river.

By this time workers in the Mayak plant were being exposed to radiation at annual doses of 2.0-4.5 Gy (Okladnikova *et al.*, Human chronic radiation sickness caused by external γ irradiation, long-term stage, *Bull. Acad. Med. Sci.* 2, 22-26, 1991). The diagnosis of CRS was made for 1,596 workers. This entity was defined by Drs. A. K.

Guskova and G. D. Baysogdolov in their book, *Radiation Diseases in Humans* (Moscow, 1971) as "a complex, clearly outlined clinical syndrome occurring as a result of the long-term exposure of the organism to radiation, single or total doses of which regularly exceed the dose permissible for professional exposure." The clinical course was marked by neuroregulatory disorders, moderate to marked leukopenia (both neutrophils and lymphocyte cells depressed), thrombocytopenia and in severe cases anemia. In severe cases atrophic changes in the mucous membrane of the GI tract, encephalomyelitis and infectious complications due to what is felt to be immune depression are noted.

Chronic radiation syndrome, however, is considered a separate clinical entity seen only in Russia and other former Soviet republics. As the authors point out, this "...oversight may be due to the fact that nowhere else but in Russia did such prolonged effects of significant rates of ionizing radiation occur in man..." In addition to the workers at Mayak, the villagers along the Techa-Isset river systems were also affected. As many as 124,000 were exposed to radiation, with 28,100 inhabitants in the regions of Chelyabinsk and Kurgan receiving doses that may have had significant health effects. Approximately 7,500 individuals had to be evacuated from their homes near the upper reaches of the Techa.

The authors have meticulously documented, to the extent possible, the doses received by a subset of 940 people who have received the diagnosis of CRS. They have recorded the doses received by many of these individuals using whole-body counters (when available) and measurements of strontium-90 β -particle radiation from tooth enamel and urine. They have listed several case histories of individuals who contracted CRS, documenting the clinical course, symptoms, hematological and other parameters as well as dosimetric data. The ages, location along the river, mean equivalent dose to the marrow from both external exposure and internal incorporation of radionu-

clides, and clinical and laboratory changes in multiple organ systems have been carefully documented.

The authors have also identified a subset of the 940 officially diagnosed cases of CRS that meet a more rigid set of diagnostic criteria: (1) Exposure for at least 3 years with individual measurements confirming at least 1 Gy of marrow dose received; (2) medical follow-up confirming the clinical manifestations considered by Guskova and Baysogdolov to be the criteria of CRS; and (3) absence of other illness with similar symptomatology. When one focuses on this subset of 66 cases, the dose-response relationship between CRS severity, hematopoietic depression and chromosomal aberrations is clearer. Of note is that of these 66 patients 4 have already died from leukemia and 2 more from other neoplastic disorders.

The authors have done an outstanding job of identifying, for the first time, members of the general population who have suffered deterministic effects from chronic exposure to ionizing radiation. Clearly the subset of 66 CRS patients needs to be studied more closely and more extensive laboratory studies performed to better elucidate the pathogenetic mechanisms likely to be responsible for

the effects seen. One of the areas of greatest public concern is what happens to those exposed to relatively low doses of "radiation" over long periods of time. This report furnishes the preliminary answers to this question. Further research and analysis are clearly needed.

A limited number of copies of the contract report are available from AFRRRI by writing Publications Division, Armed Forces Radiobiology Research Institute, 8901 Wisconsin Avenue, Bethesda, MD 20889-5603, or calling (301) 295-2017. The report is also available to qualified users from the Defense Technical Information Center, Cameron Station, Building 5, Attention: BCR, Alexandria, VA 22304-6145; telephone (703) 274-7633. Others may contact the National Technical Information Service, 5285 Port Royal Road, Springfield, VA 22161; telephone (703) 487-4650. The DTIC/NTIS accession number is A286238. AFRRRI publications are also available from university libraries and other libraries associated with the U.S. Government's Depository Library System.

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On the Issue of Citation of "Relevant" Published Studies in Widely Different Cell Systems

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I would like to comment on the issue of appropriate citation that E. L. Powers recently raised in this journal (1). Powers correctly reminds Makrigiorgos *et al.* of their failure to credit critical and pertinent prior work on N₂O sensitization of cells to irradiation. The response by Makrigiorgos (2) in defense of his omission was premised on the lack of sufficient relevancy of the bacterial studies, carried out 25 years earlier, as compared to mammalian cell studies published in 1982 by Roots *et al.* (3).

Unfortunately, this is one of many examples of the failure to properly recognize and credit earlier pioneering studies establishing a radiobiological observation but carried out using microorganisms.

Historically, a study of comparative biochemistry would strongly support the notion that the fundamental mechanisms of life are similar in all cells. It is my experience that

prior to 1956, bacterial cells were the cellular system of choice with which to quantify radiation effects at the cellular level. Puck *et al.* (4) initiated the development of similar quantitative methods for mammalian cells in 1956. At this time many of the basic radiobiological observations on the effects of biotic and abiotic postirradiation environment on cell physiology and survival had been made using bacteria and yeast. While serving as Editor-in-Chief of this journal I became acutely aware of the relevancy issue in properly referencing prior published work. I found this to be a sensitive and sometimes highly emotional issue either during manuscript review or after publication.

Webster's Third New International Dictionary defines "relevant" in part as: "bearing upon or properly applying to the matter at hand... a thing is relevant when it has a connection esp. a logical connection with a matter under