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Commentary

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Unsolved Problem "How to incorporate the dose-rate effect into evaluation of cancer risk for radiation protection"

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This theme was introduced at the symposium of the annual meeting of the Japan Radiation Research Society in 2013. Experimental and epidemiological data were analyzed there from different aspects. However, the dose-rate problem for estimating the cancer risk of radiation, despite having drawn much attention and being currently very important, is not yet solved.

The present radiation protection policy is based on the epidemiological data obtained from records of A-bomb survivors, a case of whole body acute exposure. However, radiation exposure conditions differ depending upon individual cases, such as whole body *versus* partial body, acute *versus* chronic exposure. For radiation protection purposes, the linear non-threshold (LNT) model has been applied to estimate the cancer risk of ionizing radiation by extrapolation of A-bomb data by the International Commission of Radiation Protection (ICRP) [1]. Data on human solid cancers, a mixture of various types of cancers in different organs produced by different doses and dose-rates of A-bomb radiation [2], were used as the basis of the LNT model. By dividing dose-response data into two components, low and high dose regions, i. e., low dose-rate and high dose-rate, assuming a fixed exposure time, a dose and dose-rate reduction factor (DDREF) 2 was deduced from the difference of the slope of the two curves. Logically, the LNT model is not compatible with the presence of the two components, and the DDREF value, 2, does not cover the whole range of the dose-rate.

Here we need a more realistic estimation of the dose-rate factor for radiation-induced cancer.

My attempt for analysis of the cancer risk of radiation is to express the non tumor dose, defined as the highest dose of radiation at which no statistically significant tumor increase was observed above the control level, as a function of the dose-rate [3]. A factor 16.5 was obtained for the difference in the cancer risk between A-bomb radiation and radiation at an envitonmental contamination level [4]. This factor varies as a function of the dose-rate. A large discrepancy in the dose-rate factor so far discussed depends upon the procedure of analysis and still remains unsolved.

Japan, in 2011, experienced an accident of nuclear reactors in Fukushima that spread accumulated radioactivity to neighboring environments by hydrogen explosion (not by nuclear reaction). This created much fear among the general public of a health hazard. A very strict regulatory rule was applied to residential areas in neighboring towns without consideration of the dose-rate effect, even 1 mSv per year, a value that is equivalent to the natural background radiation level. After any radiation accident, leukemia data are our most immediate concern. However, the leukemia incidence in the A-bomb data is even lower than the control level at doses below 200 mSv [5]. It would seem, then, that an overly strict regulation was applied in the Fukushima cases. And unfortunately, a regulation that is too strict creates too much fear and too much economical loss. It is therefore hoped that a more realistic dose-rate factor be incorporated in the radiation protection policy so that it contributes more to the realistic safety of radiation.

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