Inactivation of Human Cells by Heavy-ion Beams and Microdosimetric Estimates

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In the field of heavy-ion therapy and space radiation protection, the prediction of biological effects of heavy charged particles is an important problem. In microdosimetry, tissue-equivalent proportional counter (TEPC) has been often used to estimate the biological effect of ionizing radiations. We measured the radiation quality of various ion beams using a spherical TEPC, while the inactivation of in vitro human cells was investigated by colony assay.

The ion beams were provided by the Heavy-ion Medical Accelerator (HIMAC) in Chiba, NIRS, Japan. The microdosimetric spectra of photon and proton-, helium-, carbon-, neon-, silicon- and iron-ions (LET =range from 0.5 to 880 keV/micron) were measured using a spherical walled TEPC with a tissue-equivalent diameter of 1 micron at various depths in a plastic phantom. In the measurement of cell surviving curves, human salivary grand (HSG) tumor cells were used as a human tumor cell line, and GM05389 cells were used as a normal human fibroblast cell line.

The linear terms of linear quadratic model with a fixed quadratic term for surviving curves of each cell types were plotted as a function of the dose-mean lineal energy measured by the TEPC. We found that these plots agreed with the microdosimetric kinetic (MK) model [R. B. Hawkins, 1994] for ion beams with a LET value of less than 450 keV/micron as long as the saturation-corrected dose-mean lineal energy was used instead of dose-mean lineal energy with non-Poisson correction in the MK model. Therefore, in heavy ion therapy, this microdosimetric estimate of the revised MK model can help determining a clinical dose in the physical definition.