Chromosome Aberrations in Human Lymphocytes and Fibroblasts after Exposure to Very Low Doses of High-LET Radiation

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The relationship between biological effects and low doses of absorbed radiation is still uncertain, especially for high-LET radiation exposure. Estimates of risks from low doses and low dose rates are often extrapolated using data from Japanese atomic bomb survivors, with either linear or linear quadratic models of fit.

In this study, chromosomal aberrations (CA) were measured in human peripheral blood lymphocytes and normal skin fibroblast cells after exposure to very low doses (0.01 – 0.20 Gy) of 170-MeV/u 28Si ions or 600-MeV/u 56Fe ions, including doses where on average less than one direct ion traversal per cell nucleus occurs. Chromosomes were analyzed using the whole-chromosome fluorescence in situ hybridization (FISH) technique during the first cell division after irradiation, and CA’s were identified as either simple exchanges (translocations and dicentrics) or complex exchanges (involving >2 breaks in 2 or more chromosomes).

The curves for doses above 0.1 Gy (more than one ion traverses a cell) showed linear dose responses. However, for doses less than 0.1 Gy, 28Si ions showed a dose independent response above background CA frequencies. Possible explanations for our results are non-targeted effects due to aberrant cell signaling (Cucinotta and Chappell, 2010), or delta-ray dose fluctuations (Cucinotta et al., 1999) where a fraction of cells receive significant delta-ray doses (Figure 1) due to the contributions of multiple ion tracks that do not directly traverse cell nuclei where CA’s are scored. Additional findings for 56Fe will be discussed.

References:

Figure. (Left Panel) Radial dose density profile from 1 GeV/u Iron nuclei at 0.05 Gy in a 2D plane of cells (Cucinotta, et al. 1999). (Right Panel) Calculations of the distribution of delta-ray doses in cells not directly traversed by ions when on average 0.25 tracks per cell occur (Cucinotta, in preparation).