Cancer risk of low dose/low dose rate radiation: a meta-analysis of cancer data of mammals exposed to low doses of radiation

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Abstract

Linear No Threshold (LNT) model is a basic theory for radioprotection, but the adaptability of this hypothesis to biological responses at low doses or at low dose rates is not sufficiently investigated. Simultaneous consideration of the cumulative dose and the dose rate is necessary for evaluating the risk of long-term exposure to ionizing radiation at low dose. This study intends to examine several numerical relationships between doses and dose rates in biological responses to gamma radiation. Collected datasets on the relationship between dose and the incidence of cancer in mammals exposed to low doses of radiation were analysed using meta-regression models and modified exponential (MOE) model, which we previously published, that predicts irradiation time-dependent biological response at low dose rate ionizing radiation.

Minimum doses of observable risk and effective doses with a variety of dose rates were calculated using parameters estimated by fitting meta-regression models to the data and compared them with other statistical models that find values corresponding to "threshold limits". By fitting a weighted regression model (fixed-effects meta-regression model) to the data on risk of all cancers, it was found that the log relative risk [log(RR)] increased as the total exposure dose increased. The intersection of this regression line with the x-axis denotes the minimum dose of observable risk. These estimated minimum doses and effective doses increased with decrease of dose rate. The goodness of fits of MOE-model depended on cancer types, but the total cancer risk is reduced when dose rates are very low.

The results suggest that dose response curve for cancer risk is remarkably affected by dose rate and that dose rate effect changes as a function of dose rate. For scientific discussion on the low dose exposure risk and its uncertainty, the term "threshold" should be statistically defined, and dose rate effects should be included in the risk evaluation model.

KEYWORDS: dose rate effect; low dose rate; cancer risk; risk evaluation; risk model.

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