Long Term Effects of Low Dose-rate Gamma Radiation on Mouse Hematopoietic System

Background

Hematopoietic system is known as one of the most radio-sensitive tissues in the mammalian body and transient reduction of the number of peripheral blood cells can be detected by around 0.5 Gy (almost 500 times higher than natural background radiation per year) of acute exposure. However, there is little information about a variation in the number of peripheral blood cells, especially hematopoietic stem cells exposed to low dose-rate (chronic) long term whole body irradiation. Therefore, it is expected to study dose-rate effects by low dose-rate irradiation on hematopoietic system.

Objectives

To evaluate the effects of low dose-rate irradiation on mouse hematopoietic system, mice were irradiated with gamma-ray in the low dose rate long term irradiation facility and the number of peripheral blood cells (red blood cells and white blood cells) and hematopoietic stem cells were studied.

Principal Results

1. Dose rate effect in terms of the number of blood cells.

Mice were irradiated with 0.5 Gy at 0.5 Gy/min as a high dose rate or at 1.2 mGy/hr as a low dose rate. Both of the numbers of white and red blood cells were significantly decreased at a high dose-rate while such a decrease was not observed at a low dose-rate (Fig.1).

2. Long term variations of the number of blood cells by low dose rate irradiation

Chronic low dose rate irradiation for 200 days (5 Gy of accumulate dose) induced a transient reduction of the number of white blood cells in an early stage; however, it was recovered to as much as control level by further irradiation. Red blood cells also reduced slightly by 40 days irradiation but they were finally recovered to as much as control level (Fig.2).

3. Frequency of hematopoietic stem cells.

Low dose-rate gamma-ray was exposed to mouse for 3, 5, 9 or 26 weeks and the abundance of hematopoietic stem cells in bone marrow was studied. Significant differences were not shown between irradiated group and non-irradiated control (Table 1).

The results described above indicated that the effects on the number of peripheral blood cells were quite different in the case of low dose rate or high dose rate. In particular, the ability of hematopoiesis was maintained after irradiation about 10 times higher than minimum dose (0.5 Gy) which reduces the number of blood cells in the case of low dose rate.

Future Developments

We will study the mechanism of differentiation of hematopoietic stem cells into peripheral blood cells induced by further irradiation and research the limit dose of influence.

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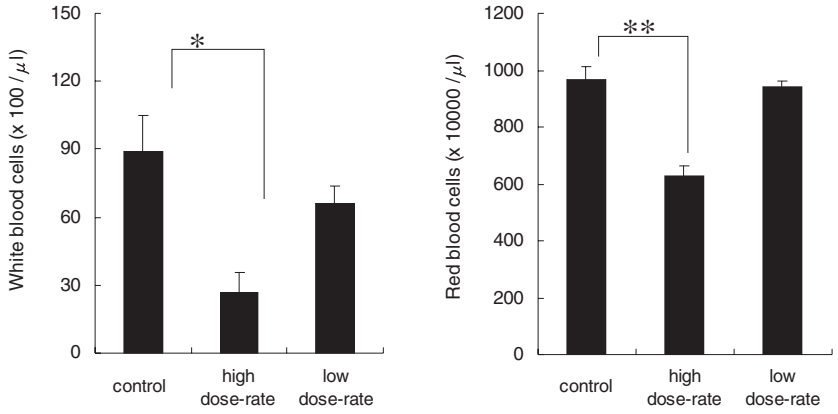
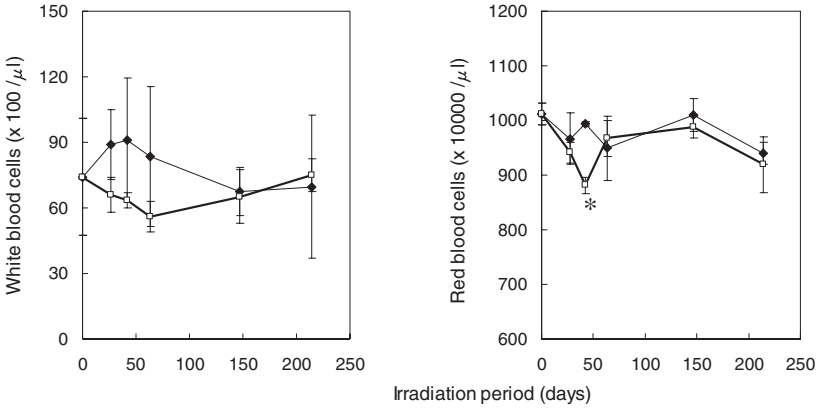
Reference

K. Otsuka, et al., 2006, “Effects for hematopoietic stem cells and peripheral blood by low dose-rate irradiation.” CRIEPI Report L05016 (in Japanese)



Whole body gamma-irradiation (0.5 Gy) was performed at 0.5 Gy/min as a high dose rate or 1.2 mGy/hr as a low dose rate. Both cell numbers reduced significantly after high dose rate irradiation while low dose rate did not induce any reduction.
(*: P<0.01,**: P<0.001,Tukey-Kramer method)

Fig.1 Dose rate effect in terms of blood cell number



◆ : non-irradiated control, □ : 1.2 mGy/hr irradiated. White blood cells slightly decreased in the early stage and red blood cells decreased by 40 days continuous irradiation. However, both cells recovered to as much as non-irradiated control level in the long term.
(*: P<0.05, Student's t-test)

Fig.2 Variation in cell number among low dose-rate long term irradiation

Table 1 Abundance of hematopoietic stem cells in mouse bone marrow

Irradiation period (weeks)	(Gy) Accumulated dose	Abundance of hematopoietic stem cells (%)		P value
		Control	Low dose-rate irradiated	
3	0.58	0.007 ± 0.001	0.004 ± 0.001	0.12
5	0.97	0.006 ± 0.001	0.003 ± 0.001	0.11
9	1.74	0.012 ± 0.001	0.010 ± 0.000	0.18
26	5.02	0.018 ± 0.009	0.021 ± 0.018	0.69

The abundance of hematopoietic stem cells in mouse bone marrow irradiated low dose rate long term (3, 5, 9 or 26 weeks) did not show significant differences compared with non-irradiated control in any irradiation periods (*: P value, Student's t-test)