Proceeding of the Korean Nuclear Society Autumn Meeting

Yongpyong, Korea, 2003

Radio-adaptive Response in Lymphocytes of Nuclear Power Plant Workers

Hee Sun Kim, Kwang Hee Yang, Suk Yong Park, Cha Soon Kim, Yong Woo Jin,

Chong Soon Kim and Yoshikazu Nishimura*

Radiation Health Research Institute, KHNP, 388-1, SSangmoon-dong, Dobong-ku, Seoul, Korea 132-703

** National Institute of Radiological Sciences, 4-9-1, Anakawa, Inage-ku, Chiba-shi, Japan 263-8555*

Abstract

Human lymphocytes pre-exposed to low doses of ionizing radiation show an adaptive response, which make these cells less sensitive to subsequent higher exposures. To verify the hypothesis that a similar phenomenon can be induced by occupationally received doses of ionizing radiation, the cytogenetic responses of fourteen nuclear power plant workers to γ-irradiation was tested. Peripheral blood lymphocytes from nuclear power plant workers were tested for their sensitivity to induction of unstable chromosome aberrations by a subsequent exposure to a high dose of γ-irradiation (2Gy). The results show that lymphocytes of occupationally long-term exposed nuclear power plant workers are not sensitized and protected to subsequent high dose radiation with unstable chromosome aberrations induction.

1. Introduction

The detrimental effects of radiation exposure have typically been attributed to its ability to cause DNA damage [1]. Fortunately, cells posses complex and efficient DNA repair process capable of recognizing and repairing most genomic damage[2]. Any cells containing misrepaired DNA damage that are not eliminated could represent at potential risk for carcinogenesis. Thus, the enhancement of error-free DNA repair pathway and apoptosis could potentially reduce the carcinogenesis risk of radiation exposure. Both processes have been shown to be affected by low doses of ionizing radiation [3]. The term 'adpative response' was

originally used to described a phenomenon in which pre-exposure of cells to a low dose of radiation rendered cells less susceptible to chromosomal damage induced by a subsequent high dose of radiation. It has been proposed that an err-free DNA repair process is induced by the low dose radiation exposure [4] such that adapted cells also show a reduction in the frequency of chromosome aberrations induced by subsequent exposure. However, the dose response relationship is not yet clear at the low dose and dose rate. Only a few cytogenetic studies of occupationally irradiated workers in nuclear power plants have been published. In the present study, we have tested the effect of pre-exposed lymphocytes to low dose of radiation in nuclear power plant on the induction of dicentric and ring chromosomes by subsequent exposure to high dose radiation.

2. Methods and Materials

Blood samples from fourteen male employees (age ranges of 30 to 44) of nuclear power plant were examined. They were technical engineers or radiation protection workers mainly in maintenance crews. All of them had received annual doses below maximum permission occupational limit of 5rem and had worked with radiation for periods ranging from 5-19 years. The accumulated doses in rem were collected monthly from physical personal dosimeter. Neither the radiation workers nor the controls had received chemotherapeutic or cytostatic drugs. Challenge doses (2Gy) were delivered at dose rate of 5Gy/min from ^{137}Cs γ-source (IBL-147). For chromosome analysis standard 48hour cultures with 0.5ml whole blood, 4ml of RPMI 1640 medium, 0.5ml fetal calf serum and 0.2ug/ml of PHA were established. A total of 9,271 cells for nuclear power plant workers and 2,408 cells for non-irradiation control were analysed. Statistical analyses were performed using Mimitab.

3. Results and Discussion

The possibility that pre-exposure of lymphocytes to a low dose radiation in nuclear power plant could modify the extent of frequency of detected dicentric and ring chromosomes induced by a subsequent high dose radiation exposure was tested (Table 1). In this study, the frequency of dicentric and ring chromosomes induced by the 2Gy challenge exposure was showed no significant different in cells that had previous received the adapting low dose of radiation in all cases of nuclear plant workers (P=0.518). An adaptive response has previously been described in lymphocytes showing that exposure to a low dose of radiation can induced a chromosomal repair mechanism such that cells subsequently exposed to a high dose display a reduced frequency of chromosomal aberrations as compared

to non-adapted cells [5]. In previous reports, moreover, induction of the adaptive response has been found to be dependent upon a number of factors including the adapting dose, dose rate, expression time [6]. The underlying mechanisms of radio-adaptation are unknown, the role of repair enzymes and/or inducible proteins as well as antioxidant free radical scavanging systems have been suggested and reflect the extreme complexity of the radio-adaptive responses in mammalian cells [7]. However, previous studies have mainly evaluated persons who received acute high-dose fractionated or received very low doses that would not be expected to result in measurable damage. The increased sensitivity may represent a novel adaptive response mechanism that could reduce the possibility that genetically damaged cells will proliferate. The results presented here demonstrate that lymphocytes exposed to a low dose rate of radiation in nuclear power plant can not become sensitized to induction of unstable chromosomal aberrations by a subsequent radiation exposure. The induction of this adaptive response were also shown to exhibit intra-individual variability. The lack of a significant response in cells from donors and intra-individual variability suggests that the induction of this response may be dependent on the physical dose, adaptation times, and physiological status of the lymphocytes at the time of blood collection [8]. Further investigations at molecular level elucidating the underlying mechanisms may perhaps help to resolve the diversity of data reported in literature and form a part of our future investigations.

4. References

1. Obe, G., Johannee, C., and Schulte-Frohlinde, D. Mutagenesis, 7, 3-12, 1992.
2. Sancar, A. and Sancar, G.B. Annual reviews in biochemistry, 57, 29-67, 1988.
3. Ikushima, T. Radio-adaptive response: Involvement of induction of specific gene expression by low doses of ionizing radiation. In low dose irradiation and biological defense mechanism, edited by T. Sugahara, L.A. Sagan and T. Aoyama, (Amsterdam: Elsevier Science Publishers), pp.255-258, 1992.
4. Seong, J., Suh, C.O. and Kim, G.E., International J. Radiation Oncology, Biology, and Physics, 33, 869-874, 1995.
5. Olivieri, G., Bodycote, J. and Wolfe, S. Science, 223, 594-597, 1984.
6. Wojcik, A. and Streffer, C. Biologisches Zentralblatt, 113, 417-434, 1994.
7. Shadley, J.D. and Wiencke, J.K. Int. J. Radiat. Biol., 56, 107, 1989.
8. Venkat, S., Chaubey, R.C. and Chauhan, P.S. Indian Journal of Experimental Biology, 34, 909-912, 1996.

Table 1. The effects of cumulative dose radiation on subsequent radiation-induced unstable chromosomal aberrations in lymphocytes of nuclear power plant workers

Donor	Occupation times (years)	Cumulative dose (rad)	Challenge dose(2Gy)	
			Before	After
1	18.7	36.13	0.0014[a]	0.44
2	17.5	23.70	0	0.35
3	16.4	17.70	0.0018	0.30
4	16.3	16.42	0.0046	0.27
5	9.3	11.82	0	-[b]
6	10.6	8.46	0	0.18
7	15.0	8.16	0	0.23
8	15.8	7.33	0.0014	0.48
9	7.3	7.43	0.0028	0.24
10	4.8	4.59	0.0013	0.21
11	13.6	4.06	0	0.65
12	6	2.7	0	0.19
13	12	1.3	0.0011	0.32
14	12	0.7	0	0.25

a: No. of cells with dicentrics+rings/scored cells, b: no tested.