International Congress Series 1276 (2005) 201–203

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Radioadaptive responses induced in lymphocytes of the inhabitants in Ramsar, Iran

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Abstract. Ramsar, a city in northern Iran, has among the highest levels of natural radiation known to exist in an inhabited area. Twenty-two residents of high-level natural radiation areas and 33 residents from an adjacent normal-level natural radiation area participated in this study. In the first phase of the experiment, 15 healthy residents from high-level natural radiation areas and 30 healthy inhabitants of a nearby normal-level natural radiation area were studied. In the second phase, seven healthy residents with cumulative lifetime doses of up to 10 Sv were studied for assessing the induction of adaptive response in each study participant and obtaining complementary data. Cultured cells were given a challenge dose of either 2 Gy (first phase of the study) or 1.5 Gy (second phase of the study) of Co-60 gamma radiation. Overall data showed a significant radioadaptive response in the residents of high-level natural radiation areas. Results obtained in the second phase of the study showed that five out of seven inhabitants exhibited a reduction in induced chromosomal aberrations following exposure to a 1.5 Gy challenge dose of gamma radiation. As the cumulative dose increased from a few hundred mGy to 1 Gy, the magnitude of the induced adaptive response increased linearly.

Keywords: Adaptive response; Natural radiation; Ramsar

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0531-5131/ © 2004 Published by Elsevier B.V.
doi:10.1016/j.ics.2004.12.002

1. Introduction

The annual effective dose (excluding radon progeny contributions) in high-level natural radiation areas (HLNRAs) of Ramsar is a few times higher than the ICRP recommended annual effective dose limit for radiation workers [1]. Our preliminary results reported previously suggested that exposure to HLNR can induce radioadaptive response in lymphocytes of Ramsar residents [2–4]. In this paper, we report the effect of cumulative dose on the radioadaptive response.

2. Materials and methods

In the first phase of the study, venous blood samples were taken from 15 and 30 healthy volunteers of both sexes who lived in HLNRAs and NLNRAs, respectively. The maximum measured dose rate of natural radiation was 155 μSv h^{-1}. In the second phase, seven healthy volunteers from HLNRAs and five healthy volunteers from a nearby NLNRAs with dose rates from 0.07 to 0.11 μSv h^{-1} served as controls. It should be noted that in the second phase, due to our selection criteria for study participants (inhabitants who received the annual doses higher than 300 mSv), only limited number of volunteers from HLNRAs were available for this study. Standard conditions for cell cultivation, irradiation and analysis of chromosome aberrations were used.

Cultured cells were given a challenge dose of either 2 Gy or 1.5 Gy of Co-60 gamma radiation at a dose rate of 114 mGy/s. Some of the culture flasks were sham irradiated to assess either the frequency of chromosomal aberrations induced by natural radiation alone in HLNRAs' residents and the spontaneous frequency of aberrations in NLNRA residents. After the challenge dose, all the culture flasks were incubated a further either 2 (first phase) or 6 (second phase) h.

For each data point, about 200 well-spread metaphases were blind scored for chromosomal aberrations. The number of chromatid-type aberrations was determined. Gaps (achromatic lesions smaller than the width of a chromatid) were included in the statistical analysis of the first phase, but in order to enhance the reliability of the results, these lesions were excluded in the statistical analysis of the second phase.

3. Results and discussion

The overall results of the first phase of our study showed a significant adaptive response when the cultured lymphocytes of the 15 inhabitants of HLNRAs were exposed to a 2 Gy gamma challenge dose (Table 1). These results confirm the previous results obtained in other in vivo human studies such as radiation worker studies.

Table 1
Mean frequency of chromatid aberrations in nonirradiated and irradiated cells of residents in HLNRAs and NLNRAs (control)

Area	No. of participants	Maximum annual dose (mGy)	MCA[a] in nonirradiated cells (gaps included)	MCA[a] in cells exposed to 2 Gy Gamma rays (gaps included)	Induction of radioadaptive response
HLNRAs	15	260	0.099±0.003[b]	0.111±0.003[b]	Positive (P<0.001)
NLNRAs	30	1.05	0.049±0.003	0.167±0.004	ND[c]

[a] Mean chromosome aberrations per cell.
[b] Mean±S.E.
[c] Not determined.

Table 2
Frequency of chromosomal aberrations in nonirradiated and irradiated cells of the residents of HLNRAs and NLNRAs

Study group	Sample size	Cumulative dose (mSv)	MCA* in nonirradiated cells[a] (gaps excluded)	MCA* in cells exposed to 1.5 Gy[a] (gaps excluded)
HLNRA	7	2534	0.014±0.004	0.106±0.015
NLNRA	5	14.6	0.016±0.002	0.188±0.020
P-value			Not significant	<0.001

[a] Mean±S.E.
* Mean chromosome aberrations per cell.

The results obtained in the second phase indicate that residents of areas with extraordinary levels of natural radiation (annual doses up to 260 mGy) show a significant radioadaptive response (Table 2). It was observed that the five persons who received cumulative doses of 360–950 mGy showed a significant radioadaptive response, while the two individuals with the highest cumulative doses (6800 and 8400 mGy) failed to show a significant radioadaptive response. That is, 70% showed an adaptive response from living in the HLNRAs. No participant from the HLNRA had an increase in radiation damage compared to the controls. We consider of great potential importance that high levels of natural radiation can serve as the priming or conditioning dose.

A relationship was found between the cumulative dose of each study participants and the magnitude of the induced radioadaptive response. Results of our experiments showed that high levels of natural radiation in inhabitants whose cumulative doses were up to 1 Gy significantly decreased radiation damage as measured by reduced chromosomal aberrations in irradiated lymphocytes. This can be considered a beneficial effect of high natural radiation.

Our findings on the biological effects of prolonged exposure to high levels of natural radiation in the inhabitants of HLNRAs of Ramsar showed no apparent harmful health effects. We have been reported previously that the health effects of prolonged exposure to high levels of natural radiation may contradict current ultra-conservative radiation protection regulations [5]. Governments should adopt public health measures and policies that are cost-effective in risk reduction by considering the financial, social and psychological impact on their citizens. Based on our results, we suggest that worldwide research on the residents of high-level natural radiation areas help scientists better justify if LNT model of radiation risk is appropriate as the basis for public health measures.

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