

Chromosome Translocation in Residents of the High Background Radiation Areas in Southern China

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We performed a cytogenetical study using chromosome painting analysis on 9 residents of the naturally high background radiation areas (HBRA) and 8 residents of the control areas in southern China. The estimated dose (air kerma) of each resident measured by an electric pocket dosimeter showed 2.20–4.23 mGy/year in HBRA and 0.56–0.70 mGy/year in the control areas. A total of 14,096 cells (1,566 cells/case) in the former and 17,522 cells (2,190 cells/case) in the latter were analyzed. Children, both in HBRA and in the control areas, had translocations at low frequencies. The frequency of translocations among elder individuals varied widely and it was not possible to detect dose effect although it was detected in dicentrics. The effect of radiation on the induction of chromosome aberrations, which have a statistically potential risk of causing malignant or congenital diseases, seems to be less significant than those of metabolic factors and/or mutagenic agents (excluding radiation) even in HBRA in China.

INTRODUCTION

Dicentrics and translocations are produced in about an equal ratio in human peripheral blood cells after exposure to radiation^{1–3}). Cells with a dicentric chromosome are destined to die through cell division and therefore have no causative effects on diseases relating to DNA change, such as malignant tumors and congenital abnormalities. On the other hand, cells with a translocation

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accumulate and could proliferate in the body without being eliminated by cell division and therefore represent a potential risk of causing those diseases.

Utilizing cytogenetic methods specifically modified for the study of the low dose effect, we showed that the frequency of dicentrics and centric ring chromosomes (Dic+Rc) increases with the cumulative dose in lymphocytes of residents in the naturally high background radiation area (HBRA) in Yangjiang, Guangdong province, Southern China⁴⁻⁶.

In the present study we report the results of the analysis of translocations found in the residents in HBRA and in the control areas.

MATERIALS AND METHODS

Major sources of the natural high level radiation are nuclides of Th-232 and U-238 decay products in the environment. Indoor and outdoor dose rates were measured using a NaI (T1) scintillation survey meter (Aloka TCS-166). Individual dose was also measured using an electric pocket dosimeter (Aloka PDM-101) for 24 h in cases other than TO01, TO03, YO01, YO03, and XO01. The method of estimation of individual dose is reported in detail⁷.

Peripheral blood samples of 9 residents in HBRA and 8 residents in the control areas were collected at their hamlets and brought to the hospital in Enping where we had established a cytogenetic laboratory. Lymphocytes were separated within 8 h after collection and they were cultured in centrifuge tubes in a water bath at 37°C for 48 h. Culture medium (6 ml consists of RPMI1640, 1% PHA, 20% fetal calf serum, 60 µg/ml Kanamycin and 0.04 µg/ml Colcemid) was prepared according to our routine method⁸⁻¹⁰. The cultured cells were harvested and fixed in the fixative solution (1:3 acetic acid/alcohol). The fixed cells were brought to the Laboratory of Industrial Hygiene (LIH), Beijing and the National Institute of Radiological Sciences (NIRS), Chiba and kept in freezers until the time of air-dry preparation. Air dried slides were made in a warm and humidified box^{11,12}. Chromosome painting was performed according to the method by Yamada et al¹³ with a slight modification as follows. Chromosome slides were treated with RNase A to remove cytoplasmic substance¹⁴, then denatured mildly in 70% formamide/2× SSC at 70°C for 50 sec. Whole chromosome painting probes (biotin labeled) for chromosomes Nos. 1, 2 and 4 (Cambio) were denatured and hybridized with the preparations at 37°C for more than 18 h. After hybridization, the preparations were reacted firstly with Avidin-FITC, secondly with Biotin-Goat-Anti-Avidin and finally with Avidin-FITC again. Then the slides were stained with propidium iodide solution (0.25 µg/ml in 2× SSC) for 3 min and sealed with a cover glass in 9:1 glycerin/PBS containing anti-fading reagent, DABCO (1,4-diazobicyclo-(2,2,2)-octane). Analysis of a painted chromosome was carried out with a B filter and its centromere was identified with a G filter under NIKON fluorescent microscopes. All the positions of abnormal cells and candidates of abnormal cells were recorded by an automated stage system and/or by a special coordinate slide. C. Wang and W. Zhang analyzed chromosome slide preparations. I. Hayata performed the final judgement of aberrations. Since a very small part of the chromosome cannot be detected by the present method, translocations include one way translocation as well as reciprocal translocations. A complex translocation involving 3 chromosomes was counted as 2 translocations.

Frequency of chromosome translocation per cell (GF, genomic frequency) was calculated according to the formula reported by Lucas et al¹⁵⁾.

RESULTS AND DISCUSSION

The case number, sex, age, dose rate, number of cells and translocations scored, genomic frequency of translocations and total dose received are given in Tables 1 and 2. Dose rates were 2.20–4.23 mGy/year in HBRA and 0.56–0.70 mGy/year in the control. A total of 14,096 cells (1,566 cells/case) in HBRA and 17,522 cells (2,190 cells/case) in the control were analyzed. Children, Y03 in HBRA and T03 in the control, had translocations in the low frequency. Figures 1 and 2 show the frequencies of translocations against age and against dose, respectively. The frequency of translocations among elder individuals is widely varied and it was not possible to detect the dose effect although it was detected in dicentrics^{4–6)}.

Table 1. Chromosome translocations detected in 8 cases in the control areas

Case	Sex	Age (y)	Cells Scored	Trans.	FG/1000 Cells	Dose/y (mGy) ^a	Total Dose (mGy) ^a
TO01	M	70.6	1424	5	9.8	0.65	45.9
TO03	M	10.4	1742	3	4.8	0.66	6.9
CO01	M	61.2	3023	19	17.5	0.70	42.7
CO02	M	57.5	2208	9	11.4	0.56	32.3
CO11	M	55.6	1116	8	20.0	0.57	31.5
CO12	M	63.3	854	4	13.1	0.56	35.3
CO13	M	55.3	873	9	28.7	0.68	37.5
CO14	M	61.1	6282	21	10.1	0.59	35.9

y: year Trans.: translocation FG: genomic frequency of trans (see text).

^aAir kerma.

Table 2. Chromosome translocations detected in 9 cases in HBRA

Case	Sex	Age (y)	Cells Scored	Trans.	FG/1000 Cells	Dose/y (mGy) ^a	Total Dose (mGy) ^a
YO01	M	89.5	2233	11	13.7	4.01	358.9
YO03	F	10.8	1015	1	2.7	4.19	45.3
XO01	M	74.5	2093	13	17.3	4.23	315.1
HO05	M	66.2	2333	6	7.2	2.28	151.3
HO06	M	55.5	1145	5	12.2	2.58	143.4
HO07	M	61.7	1376	7	14.2	2.74	168.9
HO12	M	58.5	1209	6	13.8	2.30	134.7
HO13	M	55.4	1591	10	17.5	2.58	142.8
HO14	M	54.6	1101	8	20.3	2.20	120.0

y: year Trans.: translocation FG: genomic frequency of trans (see text).

^aAir kerma.

According to the experimental studies by Lloyd et al¹⁶⁾ and Pohl-Rüling et al¹⁷⁾, induction rate of dicentrics per cGy is about 3 or less in 10,000 cells in the dose range lower than 5 cGy. As mentioned above, translocations are induced by radiation in the equal ratio with dicentrics and they are stable in the body. Therefore, if one receives 300 mGy, 9 or less number of translocations per 1000 cells may be found in the lymphocytes. However, actually observed frequencies of translocations among the inhabitants in the control areas and HBRA were higher than 9, except

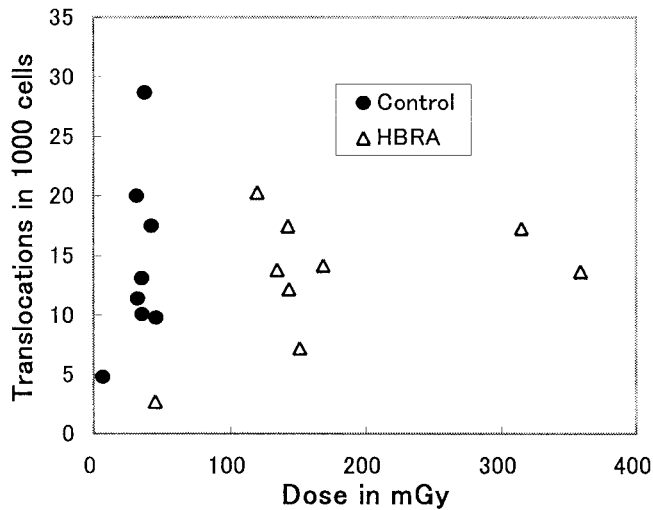


Fig. 1. Frequencies of translocations v.s. dose in the lymphocytes of residents in HBRA and in the control areas.

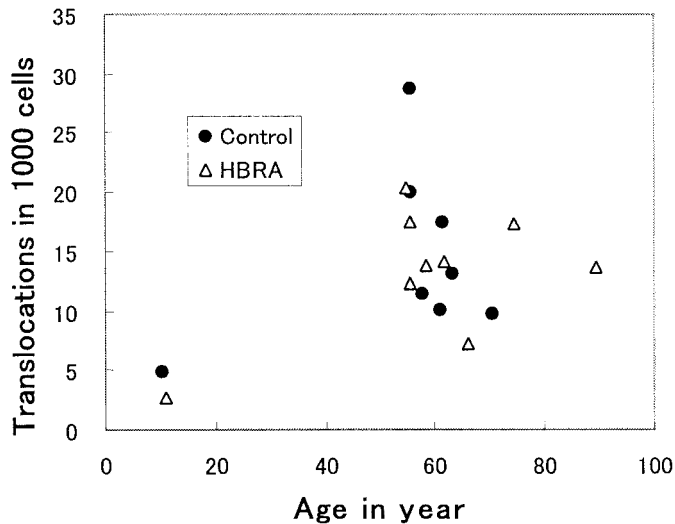


Fig. 2. Frequencies of translocations v.s. age in the lymphocytes of residents in HBRA and in the control areas.

for one case in HBRA and two children; one in the control areas and one in HBRA (Figs. 1 and 2). In addition, even for these three cases with low number of translocations, the frequencies were still much higher than the values expected from the dose they received. The effect of radiation on the induction of chromosome aberrations, which have a statistically potential risk of causing malignant or congenital diseases, seems to be less significant than those of metabolic factors and/or mutagenic agents other than environmental radiation even in HBRA in China.

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