Insignificant risk at low dose (rate) radiation predicted by cytogenetic studies

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INTRODUCTION

Effect of low dose radiation on health is an important subject in the field of radiation protection. There are several places in the world where the level of natural radiation is much higher than in other areas. Epidemiological and cytogenetical studies on the people in such areas provide good information about the effect of low dose radiation on health. We performed the cytogenetical study using conventional Giemsa staining and chromosome painting analyses on the residents of the naturally high background radiation area (HBRA) and of the control area in the southern China. In the present report the effect of low dose (rate) radiation on the human body is discussed based on the literature of the cytogenetic studies and our studies on the chromosome aberrations observed in the residents in these areas in China.

CHROMOSOME ABERRATIONS INDUCED BY RADIATION AND CHEMICAL AGENTS

When peripheral lymphocytes are exposed to radiation, practically all aberrations become chromosome type (originated from DNA double strand break) in metaphases in the first cell division after the exposure. On the other hand, chemically induced aberrations show mostly chromatid type (derived from DNA single strand break) rearrangements, which can be distinguished morphologically from chromosome type in the metaphase. Dicentrics observed in the first cell cycle are chromosome type, and they are considered as radiation induced aberrations. As for translocation, it is not possible to distinguish radiation induced ones from those induced by chemical agents. Thus dicentrics are an excellent indicator of radiation exposure and have been widely used as a key marker in the radiation dosimetry.

In the formation of exchange type chromosome rearrangements when two chromosome fragments without centromere of two chromosomes are exchanged (symmetrical exchange), two rearranged chromosomes with translocations are produced. On the other hand, when the segment having a centromere of one chromosome is exchanged with a fragment without centromere of another chromosome (asymmetrical exchange), it makes a dicentric chromosome and a fragment without centromere. Dicentrics and translocations are equally produced by radiation (1). Fifty per cent of dicentrics are eliminated through each cell division and they are called unstable type. Translocations are inherited by daughter cells and called stable type. Therefore translocations are a useful indicator of the effect of all mutagens (chemicals, metabolic factors and radiation) one has received by the time one's blood is examined.

THE LOWEST DOSE DETECTED BY CHROMOSOME ANALYSIS

Dose response of dicentric chromosomes (Dic) plus ring chromosomes (R) in the dose range below 30 cGy are reported by Takahashi et al. (2), Pohl-Rüling et al. (3) and Lloyd et al. (4,5). The results are summarized in Figure1. Linear dose response is suggested. According to Lloyd et al. (5) the increase of the frequency of dicentrics can be detected at 2 cGy and the yield of dicentrics per cGy is about 3 in 10000 cells in case of low LET radiation.

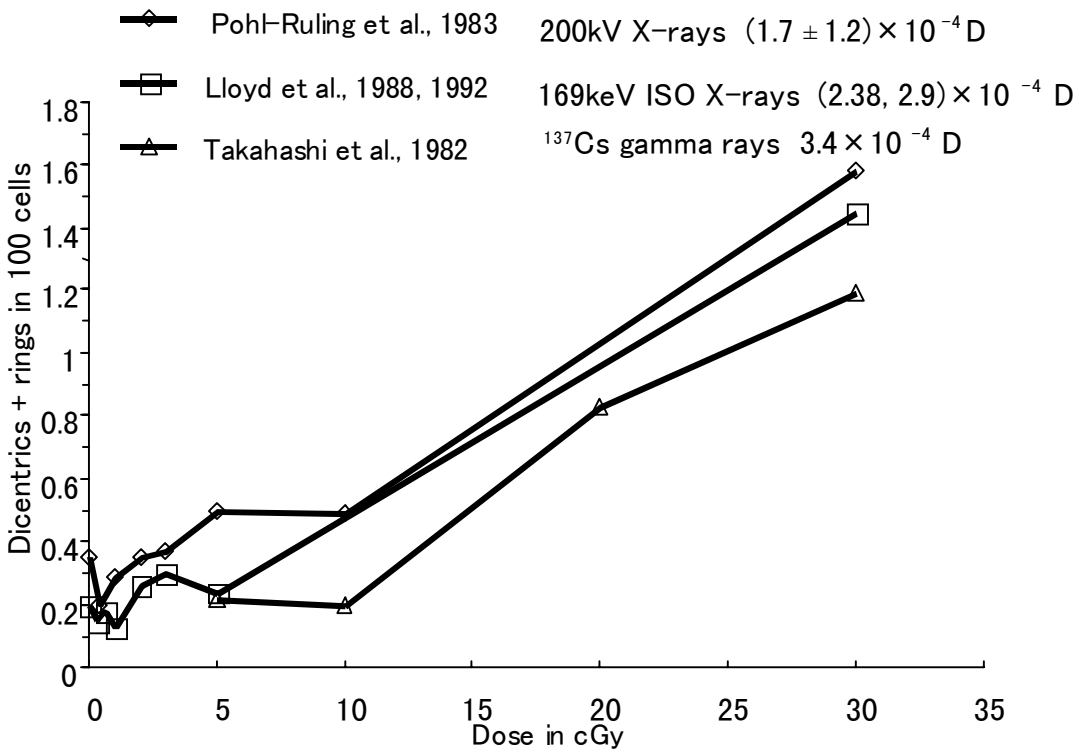

Figure 1. Dose Response in the low dose range below 30cGy

PREDICTED FREQUENCY OF RADIATION INDUCED TRANSLOCATIONS IN THE NORMAL LIVING CIRCUMSTANCE

If the average dose people were exposed could be 0.24 cGy per year (2.4 mSv per year: according to UNSCEAR 1988 Report)(6), yield of dicentrics per year would become 0.72 (3 x 0.24) in 10000 cells. Since translocations and dicentrics are equally produced by radiation, and translocations are not eliminated by cell divisions, frequency of radiation induced translocations increases linearly with the age. They would be 0.74, 1.44, 2.88, 4.32 and 5.76 in 1000 cells at the ages of 10, 20, 40, 60 and 80, respectively.

CHROMOSOME STUDY IN HBRA AND IN CONTROL AREA IN CHINA

Chromosome aberrations in the lymphocytes of residents in HBRA and control area in the south of China are reported by Jiang et al. (7) and Hayata et al. (8). The level of radiation in HBRA is 3 to 5 times higher than that in control area. Frequency of dicentrics (Dic) and ring chromosomes (Rc) increases in proportion to the accumulative dose. The increase of the frequency in such extremly low dose rate exposure suggests that there is no threshold dose in the induction of chromosome aberrations. However, no radiation effect was detected in the frequency of translocations among those people (Figures 2 and 3). All the points in Figure 2 stay below 6 while all those in Figure 3 are above 6 except for 2 children's points. It seems that the effect of radiation on the induction of chromosome aberrations are buried within the extent of the effects of metabolic factors and chemical agents even in HBRA in China.

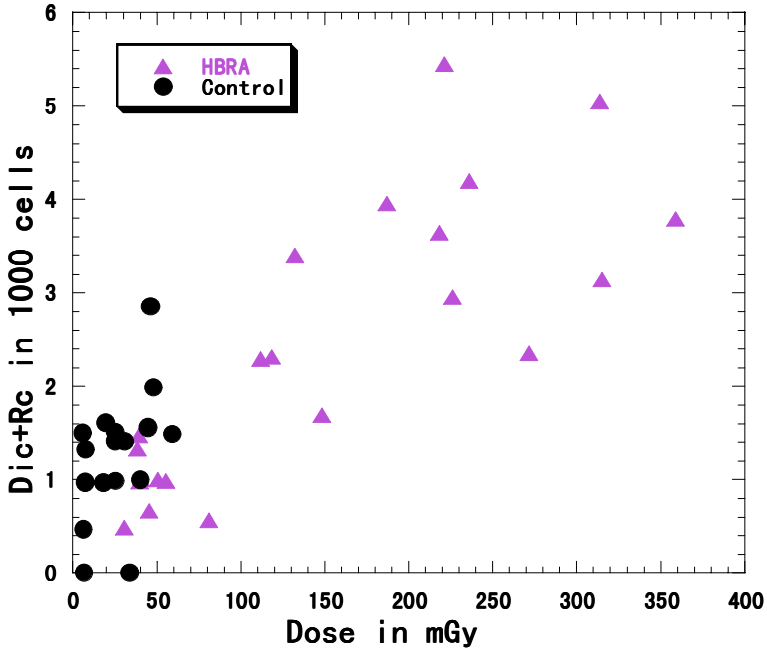

Figure 2. Frequency of dicentrics and ring chromosomes observed in the residents in HBRA and control area.

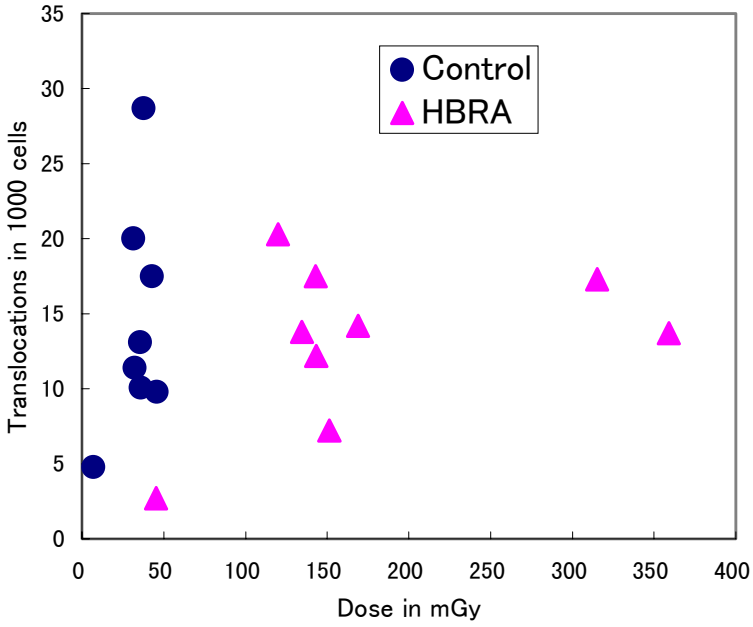

Figure 3. Frequency of translocations observed in the residents in HBRA and control area.

FREQUENCY OF STABLE TYPE ABERRATIONS IN CONTROL POPULATIONS IN THE USA

Tucker et al. (9) and Ramsey et al. (10) analyzed stable type aberrations (translocations + insertions) in lymphocytes in control populations. According to Ramsey et al., the yield of stable type aberrations in 1000 cells are 2.37, 7.22 and 25.6 at the ages of 0, 19-49 and over 50, respectively. The frequency of insertions is much lower than that of translocations (our own unpublished data). When these values are compared with the calculated values mentioned above, it is obvious that the effect of radiation on the increase of stable type aberrations is much lower than these of non-radiation mutagens and metabolic factors especially in old people.

CONCLUSION

It seems there is no threshold of radiation dose in the induction of chromosome aberrations which have statistically potential risk of causing malignant or congenital diseases. But the effect of radiation on the induction of chromosome aberrations are buried within the extent of the effects of metabolic factors and/or mutagenic agents (excluding radiation) at least up to the dose 3 times higher than normal level.

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