CHROMOSOMAL ABERRATION ANALYSES OF BYELORUSSIAN CHILDREN EXPOSED TO CHERNOBYL FALLOUT

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ABSTRACT

The radiation exposure of 26 Byelorussian children visiting Finland in summer 1990 was estimated by chromosomal aberration analyses and whole body counting. For comparison, twelve children from southern Finland were studied similarly. In general, the children were healthy and blood pictures and thyroid function tests were within the normal range. In the whole body measurements, the only nuclides detected were cesium-137 and cesium-134. The cesium body contents of the Byelorussian children were low (mean 6.3 Bq/kg of ^{137}Cs and 0.4 Bq/kg of ^{134}Cs), similar to those of the Finnish children. However, the Byelorussian children had significantly higher frequencies of radiation-related chromosome-type aberrations in their lymphocytes than the Finnish children.

INTRODUCTION

After the Chernobyl accident, many controversial reports have appeared of the radiation exposure and the possible health impact of the population living in the most affected areas. Also in the field of biological dosimetry the data are either inadequate or puzzling. Without any actual figures published, local studies have been described where no differences in the chromosomal aberration frequencies have been observed between the subjects living in contaminated or control areas. On the other hand, scientific papers report unexpectedly high aberration frequencies after exposures to minimal radiation doses from cesium in Central Europe.

We have estimated the radiation exposure of 26 Byelorussian children visiting Finland in summer 1990, four years after the Chernobyl accident, by whole body counting and chromosomal aberration analyses, and compared the results to Finnish children of the same age. Also the health status of the visitors was investigated.

MATERIAL AND METHODS

There were 15 girls and 11 boys in the Byelorussian group and their mean age was 14 years. The children originated from the Minsk, Mogil'ov and Gomel areas. Of these, the Gomel area is the most polluted by Chernobyl fallout, and the Minsk area the least. The surface contamination of cesium-137 in the Gomel area typically ranges from 37 to more than 1480 kBq/m^2, in the Mogil'ov area from less than 37 to 555 kBq/m^2, and is less than 37 kBq/m^2 in the Minsk district. In the Gomel region, there are also minor areas contaminated by strontium-90 with surface activities from 37 to 111 kBq/m^2.

The health status of the children was clarified by intervues and clinical investigations. Information was obtained on

diagnoses given to the children in Byelorussia. In Finland, every child went through a physical examination made by a general practioner, and a few were referred for a specialist consultation. All the children were investigated for complete blood picture including differential count of leukocytes; free thyroxine, and thyroid-stimulating hormone. Other tests were made if indicated.

The activity in the body was measured using two whole-body counters. The IRMA 1 whole-body counter, installed in an iron room, uses a multidetector scanning technique, with four NaI(Tl)-chrystals. The scanning time is 30 minutes and the minimum detectable activity (MDA) for cesium-134 and cesium-137 is 30 Bq. The mobile IRMA 2 whole body counter has a measuring geometry of chair type and a high purity germanium detector with 27 percent efficiency. The measurement time is 1,000 seconds and the corresponding MDA for cesium-134 and cesium-137 about 50 Bq.

Routine 48-hour lymphocyte cultures were established and 200 cells from each subject were analysed for chromosomal aberrations. The chromosomal aberrations scored included both chromatid aberrations (breaks, gaps) and chromosome-type aberrations (breaks, gaps, dicentrics, rings, translocations and inversions). The results of chromosome aberration analyses were tested by Fisher's exact probability test.

For the results of whole body measurements and chromosomal analyses, the Byelorussian children were compared to twelve children from the southern Finland, matched by age, sex, and X-ray examinations. The control children originated from an area where the surface activity of cesium-137 was less than 6 kBq/m^2.

RESULTS

Generally, the children were in good health, and no major health problems were noticed. A clear discrepancy was noticed between diagnoses given them in Byelorussia and the scarcity of findings during their stay in Finland. Diagnoses like gastritis, arthritis, and neurocirculatory dystonia were frequent but, as a rule, could not be confirmed. Six of the children were reported to have an enlarged thyroid, which is not surprising, as they come from an area in which goiter is endemic. Four of these cases could be confirmed at the time of the examination in Finland. All of the children were, however, clinically euthyroid. The thyroid function tests were all in the normal range. The blood pictures were all normal except two cases of eosinophilia and two cases of slight anemia of iron deficiency type.

The results of the whole body measurements are shown in Table 1. The only Chernobyl fallout nuclides found were cesium-137 and cesium-134, with mean activities of 6.3 Bq/kg and 0.4 Bq/kg, respectively, in the Byelorussian group. The children from the Mogil'ov and Gomel districts tended to have higher values than those from the Minsk district, as could be expected by the distribution of surface ground contamination. As a whole, however, the cesium body contents of the Byelorussian children were low, similar to those of the Finnish children living in much less contaminated areas.

The internal mean effective dose equivalent delivered in 1990 from radiocesium to Finnish children was less than 0.05 mSv. The total internal dose delivered to the Finnish children studied from

1986 to 1990 was about 0.2 mSv. The external dose equivalent during the same time period was higher and the total mean effective dose equivalent 1986-1990 was estimated at 0.6 mSv. For the Byelorussian children studied, no information on temporal behaviour of radiation doses after the Chernobyl accident was available.

Table 1 The whole body contents of Chernobyl fallout nuclides in the Byelorussian children and the controls

Region	No. of subj.	Cesium-137 Bq/kg, mean (range)	Cesium-134 Bq/kg, mean (range)
Minsk	10	4.0 (3.2-5.2)	0.3 (0-0.8)
Mogil'ov	15	7.6 (3.1-14)	0.4 (0-2.0)
Gomel	1	9.2	1.5
Total	26	6.3 (3.1-14)	0.4 (0-2.0)
Control (Finland)	12	7.5 (1.1-14.4)	1.2 (0.5-2.7)

The frequency of the radiation-related chromosome-type aberrations was significantly (P=0.046) higher among the Byelorussian children than among the Finnish children, whereas there was no difference in the frequency of chromatid aberrations, that are not typically induced by ionizing radiation in resting lymphocytes (Table 2). The children from the more heavily contaminated areas of Gomel and Mogil'ov had more chromosome-type aberrations in their lymphocytes than those from Minsk, and the control children from the least polluted area also had the lowest number of aberrations.

The frequency of dicentric chromosomes was almost four-fold (1.5×10^{-3}) in the Byelorussian group as compared to the Finnish children (0.4×10^{-3}); this difference was not, however, statistically significant (P = 0.167). An absorbed dose of 100 mGy of ^{60}Co gamma radiation raises the number of dicentric chromosomes to about 4 or 5 per thousand lymphocytes from the control value of less than 1/1000. Assuming a dicentric half-time of 3 years, and that the majority of the radiation dose was delivered shortly after the accident, the average exposure of the children in this group could be as high as 100 mGy. However, this estimate is complicated by an uneven distribution of dicentrics between the cells analysed. As the cesium body contents of the Byelorussian children were similar to that of the Finnish children, most of their radiation exposure must have come from other sources, eg. external radiation.

Table 2 The frequency of chromosomal aberrations among the Byelorussian children and the Finnish controls

Region	No. of subj.	Aberrations per 1000 cells Ct	Cs	Dic, r
Minsk	10	2.0	3.6	1.0
Mogil'ov	15	1.7	4.3	2.0
Gomel	1	5.0	20.0	0
Total	26	1.9	4.6*	1.5
Control	12	1.3	2.1	0.4

* P=0.046, Fisher's exact probability test
Ct, chromatid aberrations; Cs, chromosome-type aberrations; Dic, dicentric chromosomes; r, rings

CONCLUSIONS

Comparison of Byelorussian children to Finnish children showed that their cesium body contents are similar. It thus appears that the Soviet authorities have applied strict dietary restrictions within the areas studied, at least recently. However, the Byelorussian children had significantly higher frequencies of radiation-related chromosome-type aberrations in their lymphocytes.

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