



ENHANCED FREQUENCY OF CHROMOSOMAL ABERRATIONS IN WORKERS OCCUPATIONALLY EXPOSED TO IONIZING RADIATIONS

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Summary. *The yield of chromosomal aberrations was analyzed in peripheral blood cultures to estimate the level of radiation exposure in workers from a radioprotection department. The subjects were exposed at low level dose rate (external exposure) to alfa, beta and gamma rays for time periods ranging between 7 and 34 years. We found a higher frequency of dicentrics and acentrics than in the control group. The absorbed dose cumulated during the total period of employment in radiation field (calculated by extrapolating in vitro dose-response curve for dicentrics), ranged between 113.7 and 281 mGy. The average annual dose rate (assessed between 3.8-16.2 mGy/y) was below the permissible limit of 50 mGy/year for the whole body. There was no clear trend between the enhanced number of dicentrics and the age or exposure period of the subjects.*

Key words: *Chromosomal aberrations, ionizing radiation, low level dose, alpha, beta, gamma rays, exposure period*

Introduction

Workers from radioprotection department are occupationally exposed at low-level dose and dose rate (external exposure) to alpha, beta and gamma rays. There is little available information about low level exposure. One of the reasons is the difficult evaluation of the damages induced by ionizing radiation among the other environmental agents in human's (1). Bigatti et Lamerti (1988) (2) showed an increased number of chromosomal aberrations, including dicentrics in hospital workers (physicians, nurses and technicians) who were exposed to low levels of X or gamma rays. Jha and Sharma (1991) (3) found an enhanced frequency of dicentrics and acentrics in workers handling diagnostic X-ray machines. The estimated level of exposure was between 0.13 and 0.17 Gy. The present study tries to estimate the extent of exposure in workers from a radiohygiene department from Timisoara, Romania.

Material and Methods

We selected the workers with more than five years of employment in the radiation field from a radioprotection department. The control individuals were selected to match the mean age and sex of the exposed group. Peripheral blood samples were collected from 10 workers and 24 healthy donors (the control group). Blood samples were drawn into heparinised tubes. Whole blood (0.5 ml) was added to 4.5 ml RPMI me-

dium containing 15% fetal calf serum, 2 mM glutamine, 2% phytohemagglutinin P (Sigma), 100 units/ml penicillin and 100 µg/ml streptomycin. The blood was cultured at 37°C for 48 hours. Colcemid (0.20 µg/ml) was added 2 h prior to harvesting. Fixation was performed by standard cytological procedures i.e., cells were exposed to a 0.075 M KI solution for 12 minutes at 37°C and then were fixed in methanol-acetic acid mixture (3:1) freshly prepared. Preparations were made by dropping the final suspension onto wet slides and staining with Giemsa 5%. At least 500 metaphases were analyzed for each subject.

Chromosomal aberrations were recorded separately but only the number of dicentrics and acentrics were the object of our interpretations. For assessing the absorbed doses we used the gamma-ray calibration curve with its 95% confidence limits:

$$Y = 0.0005 + 1.64 \cdot 10^{-4}D + 4.92 \cdot 10^{-6}D^2 \quad (2)$$

The corresponding average annual dose rate was calculated for each subject.

Results

The yield of chromosomal aberrations (dicentrics and acentrics) in exposed workers is summarized in Table 1. The frequency of dicentrics was enhanced in the exposed group when comparing with the controls. The mean values were $3.2 \cdot 10^{-3}$ dic/cell for workers and 10^{-3} dic/cell for control individuals.

Table 1. The yields of dicentrics and acentrics and estimated absorbed doses in occupationally exposed workers

Subject	Age (years)	Time of exposure (years)	Cells scored	Dicentrics (dicentrics/ 10^3 cells)	Acentrics (acentrics/ 10^3 cells)	Dose (mGy/y)	Dose rate (mGy/y)	95% Confidence	limits (mGy)
1	44	15	490	2(4.08)	11(22)	181	12	0	343
2	55	31	500	4(8.0)	8(160)	281	9	72	461
3	55	34	500	3(6.0)	6(12)	233	6	22	405
4	52	15	503	2(3.9)	8(15)	177	11	0	338
5	57	30	498	1(2.0)	10(20)	113	30	0	252
6	33	7	500	1(2.0)	7(14)	113	16	0	252
7	39	11	500	0(0)	6(12)	0	0	0	0
8	39	9	500	1(2.0)	6(12)	113	12	0	252
9	60	34	500	2(3.9)	20(40)	177	16	0	339
10	52	20	500	0(0)	6(12)	0	0	0	0

Among the ten studied workers, dicentrics were not observed in two cases meaning that they practically received zero mGy/y. The highest value of 8×10^{-3} dic/cell was noticed in one case.

The absorbed dose cumulated over the total period of employment ranged from 113 to 281 mGy. The average annual dose had values between 3 and 16 mGy/y indicating an exposure below the permissible limit of whole body exposure of 50 mGy/y for workers.

Table 2 shows the comparison of chromosomal aberrations in two groups: control and exposed workers. The frequency of acentrics was also higher in the exposed group. We noticed the prevalence of minutes among the acentrics in exposed individuals (65 minutes out of 88 acentrics, meaning 73.9%).

is above 150 mGy (Purrott et al., 1974) (5).

Many factors could influence the absence of a clear dose dependent response (Bauchinger et al., 1980) (4). It is well known that among individuals differences could exist in proliferative rate of PHA-responsive lymphocytes in culture. This would influence the in vivo dose-response relationship (Crossen, 1977) (6).

Investigations at low dose response require scoring a large number of cells (more than 1.0) for a greater accuracy.

There is evidence that unstable chromosomal aberrations are related with cancer disease. The Philadelphia chromosome, a 9/22 reciprocal translocation, has been associated with chronic myeloid leukemia and the 14/18 translocation is related to acute lymphocytic leukemia (Evans, 1987) (7). Those two diseases are known to be

Table 2. Comparison of yields of dicentrics and acentrics in control and exposed individuals

Group	Number of individuals	Mean age (years)	Cells scored	Dicentrics (dicentrics/cell $10^3 \pm SD$)	Acentrics (acentrics/cell $10^3 \pm SD$)
Control	24	45.2	11968	1(0.08)	73(6.09)
Exposed	10	48.6	4991	16(3.20)	88(17.63)

Discussion

The present results give evidence about the level of exposure in workers from a radioprotection department.

The type of exposure is chronic with low levels of alpha, beta and gamma rays (external exposure). The workers are permanently wearing a dosimetry film which monthly provides the physical dosimetry. No case of overexposure was recorded.

We found without any doubts an increased frequency of dicentrics and acentrics in the exposed workers. We did not notice a clear trend of increased aberrations as a function of age or years of employment.

A similar observation was obtained in the studies of Bauchinger et al, (1980) (4), Bigatti et al, (1988) (2), Jha et al, (1991) (3).

The cytogenetic dosimetry has its practical limitations particularly for low dose estimation. Based on in vitro studies, it has been suggested that no dicentrics in 500 cells scored estimates a zero dose, but on the other hand there is a 1 in 40 chance that the dose

is inducible by radiation. Almost all cancerous cells are chromosom unstable.

Dicentrics are a frequent feature of transformed cells and many tumors are characterized by a great number of minutes.

The spontaneous yield of acentrics is higher than of dicentrics meaning that acentrics could be induced by other factors than ionizing radiation. The frequency of acentrics is considerable higher in workers exposed to radiation. In such cases, as explained by Lea (1955) (8) acentrics are largely "single hit" in origin, whereas dicentrics are "double hit" events (Purrott et al., 1973) (5).

Conclusions

The risk assessment in occupationally exposed people at low doses and dose rate is difficult and involves an inevitable degree of interpretation. The need for better information, which can be used in formulating recommendations for the radiobiological protection of workers and the general population, remains permanent.

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POJAČANA FREKVENCIJA HROMOZOMSKE ABERACIJE KOD RADNIKA PROFESIONALNO IZLOŽENIH JONIZUJUĆIM ZRAČENJIMA

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Kratak sadržaj: Područje hromozomskih aberacija je analizirano u perifernoj kulturi krvi da bi se odredio nivo radioaktivne ekspozicije kod radnika iz odeljenja zaštite od zračenja.

Ispitanici su bili izloženi niskim dozama radijacije (spoljna ekspozicija), alfa, beta i gama zracima u vremenskom periodu koji je trajao između 7 i 34 godina. U eksponovanoj grupi otkrivena je veća učestalost dicentričnih i acentričnih hromozoma nego što je to bio slučaj u kontrolnoj grupi. Apsoorbovana doza je akumulirana za vreme čitavog perioda ekspozicije u radioaktivnom polju (izračunata ekstrapolacijom in vitro dozi-krivulja reakcije za dicentrične hromozome) i to u polju dejstva između 113,7 i 281 mGy.

Prosečna stopa godišnje doze (procena između 3,8–16,2 mGy/y) bila je ispod dozvoljene granice od 50 mGy/y za celo telo. Nije postojala direktna veza između pojačanog broja dicentričnih hromozoma i perioda izloženosti ispitanih.

Primećena je pojačana učestalost dicentričnih hromozoma eksponovane grupe statistički značajnije u odnosu na kontrolnu grupu.

Ključne reči: Hromozomska aberacija, jonizujuće zračenje, nizak nivo doze, alfa, beta i gama zraci, period ekspozicije

Received: May 29, 1998