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Chromosomal Aberrations in the Leucocytes of Men Occupationally Exposed to Uranyl Compounds

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Since 1970 nuclear power stood among the fastest developing sources of energy and has been making significant contribution to electricity supplies in many countries. So, the use of uranium as fuel in nuclear power industry has augmented mining, milling, processing and enrichment of uranium. This resulted in increased environmental exposure of man to this element.

In uranium mines and mills workers are generally exposed to three different radiation components like gamma radiation, radon daughters and radioactive dust of air-borne uranium ore or concentrate (Duport et al. 1988). In uranium mines where thorium is also present in the ore, there is increase in the number of radiation components with the inclusion of thorium-laden dust. In uranium processing plants where enrichment of uranium takes place, besides the soluble and insoluble forms of uranium the workers are also occupationally exposed to toxic agents like phosgene gas, mercury, and organic solvents like carbon tetra chloride, trichloroethylene etc (Anthony and Frome, 1981).

Studies carried out in uranium miners have revealed the mutagenic Martin et al 1991) and carcinogenic (Axelson and Forastiere, 1993; Moolgavkar et al 1993) effects of occupational exposure to uranium and its daughter products. Such studies in workers employed in nuclear fuel facilities are rather scanty (Prabhavathi et al, 1995a,b; 2000). Hence we evaluated the cytogenetic effects in non-smoking and non-alcoholic uranium workers.

MATERIALS AND METHODS

160 nonsmoking workers in the age group of 23-50 years employed in a nuclear fuel facility formed the subjects of the present study. Their service in the facility ranged from 1 to 25 years. They worked in four major plants in the facility namely, uranium oxide plant, enriched uranium oxide plant, ceramic fuel fabrication plant and enriched fuel fabrication plant. Besides uranyl compounds like uranium dioxide, uranium trioxide, uranyl flouride, uranyl nitrate they also

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handled some chemicals like ammonia, nitric acid, tributyl phosphate etc. All the subjects were nonalcoholics and were on normal diet.

For comparison, 118 non-smoking and non-alcoholic, age matched controls with no history of occupational exposure to uranium or other chemical compounds, belonging to the same socio-economic status as that of the workers were also studied.

Heparinised blood samples were drawn from all the 278 subjects and peripheral blood lymphocyte cultures were carried out following the standard method of Moorhead et al (1960) with slight modifications to suit our laboratory conditions. 0.5 ml of whole blood of each sample was cultured in RPMI 1640 medium supplemented with 25% human AB serum, 0.5% phytohaemagglutinin-P and 0.25% antibiotic (dicrysticin-S). The culture vials were incubated at 37°C for 72 hours. Colchicine solution was added to the cultures at 70th hour arrest the cell division at metaphase stage. Slides were prepared and air-dried. All slides were coded and stained in giemsa. For each sample, 150 well spread metaphases with were screened for various structural and numerical type of aberrations. The results were statistically analysed using chi-square test.

RESULTS AND DISCUSSION

The data on the incidence of different types of aberrations are presented in the table-1. The results indicate a significant increase in the frequency of aberrations in the nonsmoker exposed group (6.32%) compared to the frequency (1. 02 %) in the control group ($p<0.05$). The frequencies of chromatid gaps, breaks and acentric fragments in the exposed group were 2.45, 1.95, 1.19% as against 1.02, 0.58, 0.20% in the controls respectively. While no exchanges were recorded in the control group, a frequency of 0.15% was recorded in the exposed group. Dicentrics (1.22%), polyploids (1.44%), ring chromosomes (0.10%) were observed only in the exposed group.

The frequencies of aberrations when analysed according to the service of the workers in the facility revealed an increase in the frequency of total aberrations with duration of service of the workers (Table-2). The percentages of aberrations were 4.63, 5.65, 6.23, 6.80 and 7.12 in the workers who had 1-5, 6-10, 11-15, 16-20 and 21-25 years of service respectively. These frequencies at each time interval significantly differed from the frequency of aberrations in the control group ($p<0.05$). Except between 1-5 and 6-10 years, 16-20 and 21-25 year groups, the differences in the frequencies of aberrations inbetween the rest of the time intervals were found statistically significant ($p<0.05$).

Table 1. Data on chromosomal aberrations in control and exposed group (nonsmokers).

	Control Group	Exposed Group
Number of men	118	160
Number of metaphases screened	17,700	24,000
Number of chromatid gaps	180 (1.02)	588 (2.45)
Number of chromatid breaks	102 (0.58)	467 (1.95)
Number of chromatid type acentric fragments	36 (0.20)	285 (1.19)
Number of isochromatid gaps	8 (0.05)	215 (0.90)
Number of isochromatid type breaks	22 (0.12)	184 (0.77)
Number of isochromatid type acentric fragments	21 (0.12)	227 (0.95)
Number of exchanges	0 (0.00)	36 (0.15)
Number of dicentrics	0 (0.00)	292 (1.22)
Number of ring chromosomes	0 (0.00)	25 (0.10)
Number of polyploids	0 (0.00)	346 (1.44)
Total number of aberrations (excluding gaps and polyploids)	181 (1.02)	1516 (6.32)*

Values in the parantheses indicate percentage.
*p<0.05

Table 2. Analysis of chromosomal aberrations according to duration of exposure in the nuclear fuel workers.

Group and Years of exposure	No. of samples	Total no. of aberrations (Mean ± SE)
Control group	118	181(1.02 ± 0.30)
Exposed group		
1-5	18	125 (4.63 ±1.51)*
6-10	25	212 (5.65 ±1.65)*
11-15	37	346 (6.23±1.02)*
16-20	45	459 (6.80±1.11)*
21-25	35	374 (7.12±1.21)*
Total	160	1516 (6.32±0.87)*

*p<0.05

The study showed a significant increase in the incidence of chromosomal aberrations in the workers occupationally exposed to uranyl compounds. The results are in accordance with our recent reports where we presented an evidence for the clastogenic effects in men exposed to uranium compounds (Prabhavathi et al. 1995 a,b; 2000). Earlier, Martin et al. (1981) reported significant increase in the frequencies of chromosomal aberrations and SCEs in workers exposed to soluble uranium compounds.

Exposure to uranium includes both external and internal radiation. As external exposure to radiation is negligible in uranium workers, the main hazard is associated with inhalation or ingestion of uranium compounds because the internally emmitted alpha radiations are readily absorbed by the tissue. Studies conducted in hamster and human cell lines have revealed the genotoxic effects of such alpha radiation (Aghamohammadi et al. 1988; Nagasawa et al. 1990). While this is in the case of insoluble uranium, soluble uranium enters the blood stream and reaches every part of the body via circulation. Deposition of insoluble uranium compounds in kidneys, skeleton, liver and lungs was reported (Ballou et al. 1986; Morrow et al. 1982). Studies have revealed the toxic, mutagenic, biochemical and teratogenic effects of uranium compounds like uranyl nitrate, uranyl fluoride etc., in different test systems (Lin et al. 1993; Hu and Zhu 1990 a,b)

Epidemiological studies have reported increased incidence of cancers predominantly lung cancer in population exposed to radon, the daughter product of uranium (Baisogolov et al. 1991; Moolgavkar et al. 1993, Piao et al. 1993, Tomasek et al. 1994). Anthony and Frome (1981) reported increased lung cancer deaths in men employed in a uranium processing plant occupationally exposed to radon free uranium. The carcinogenic effects of uranium compounds are well documented in animals (Ballou 1986; Lang et al.1993). Thus exposure of man to uranium compounds might result in health hazards in the long term.

The present study presented evidence for the clastogenic effects of uranyl compounds in workers. This could be due to incorporation of radionuclides in their body and the cumulative effect of both radioactivity and chemical toxicity of uranium and its compound forms. The results suggest that these workers should take appropriate precautions to prevent undue exposure to uranyl compounds.

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