CHROMOSOMAL ABERRATIONS IN CELLS OF MONKEYS SURVIVING ACUTE RADIATION UNDER CHEMICAL PROTECTION

L. P. Kosichenko and L. F. Semenov*

UDC 612.6.05:575.224.23].
014.482:615.849.1.015.5

In the study of the frequency and type of chromosomal aberrations in bone marrow cells and peripheral blood lymphocytes of irradiated monkeys treated 5-10 min before irradiation with the protective compounds 5-methoxytryptamine and 2-aminoethanethiol, etc., showed that 9-10 years after γ-ray irradiation in doses of 600-650 R the percentage of aberrant chromosomes was significantly higher than the spontaneous level and was at the level of chromosomal changes observed in monkeys irradiated without the use of radioprotectors. In the late period after irradiation, the main type of aberration observed in all monkeys, including those receiving the radioprotectors, was symmetrical chromosomal exchanges.

KEY WORDS: *irradiation; radioprotectors; bone marrow; chromosomal aberrations.*

The phenomenon of prolonged persistence of a raised percentage of chromosomal aberrations in the somatic cells of irradiated animals has now been firmly established [6, 7, 11-13]. The problem of late cytogenetic changes in organisms irradiated following administration of chemical protectors has been insufficiently studied. Meanwhile the high percentage of exchange aberrations persisting for a long time in somatic cells after irradiation points to the need for a search for preparations that will protect chromosomes against the action of ionizing radiation.

The object of this investigation was to study the genetic apparatus of bone marrow cells and peripheral blood lymphocytes of monkeys surviving a single acute irradiation following chemical protection.

EXPERIMENTAL METHOD

Experiments were carried out on 12 rhesus monkeys aged 12-15 years. Five healthy monkeys of this group acted as the control and received no treatment. The remaining seven monkeys aged 3-5 years were exposed to whole-body irradiation in a cobalt γ-ray source in doses of 600-650 R; four monkeys of this group received radioprotectors by subcutaneous injection in aqueous solutions in a volume of 0.2-0.3 ml 5-10 min before irradiation in the following combinations:

1) Monkey No. 3149 received tryptamine in a dose of 160 mg/kg body weight com-

*Deceased.

Institute of Experimental Pathology and Therapy, Academy of Medical Sciences of the USSR, Sukhumi. (Presented by Academician of the Academy of Medical Sciences of the USSR B. A. Lapin.) Translated from Byulleten' Éksperimental'noi Biologii i Meditsiny, Vol. 80, No. 8, pp. 109-112, August, 1975. Original article submitted May 12, 1974.

TABLE 1. Frequency and Types of Chromosomal Aberrations in Monkeys in Late Periods after Acute Irradiation (calculated per 100 cells)

Type of aberration	Control		Irradiation					
			No. 3954		No. 4245		No. 4248	
	A	B	A	B	A	B	A	B
Single fragment	0,4	1,03	1,0	1,37	0,5	1,5	0,5	2,0
Paired fragments	0,88	0,42	1,5	2,1	1,0	2,0	1,0	0,0
Symmetrical exchanges	0,0	0,67	17,0	13,8	13,5	27,0	18,0	9,95
Asymmetrical exchanges	0,0	0,0	0,0	0,7	0,5	0,5	0,5	0,0
Total number of aberrations . . .	1,28±0,3	2,12±0,3	19,5±2,1	17,93±3,2	15,5±2,5	31,0±1,0	20,0±3,1	11,95±3,1
Number of cells studied	1030	915	200	145	200	200	200	100

Type of aberration	Irradiation + chemical protection							
	No. 3149		No. 3150		No. 3276		No. 6172	
	A	B	A	B	A	B	A	B
Single fragment	0,0	1,82	1,82	0,0	2,1	0,0	0,6	0,0
Paired fragments	0,0	0,0	0,45	1,0	1,0	0,5	1,95	0,5
Symmetrical exchanges	21,5	19,98	19,1	14,0	17,9	14,5	18,35	7,5
Asymmetrical exchanges	0,5	0,0	0,45	1,0	0,0	0,0	0,0	0,0
Total number of aberrations . . .	22,0±3,0	21,8±2,7	21,82±2,78	16,5±3,7	21,0±2,8	15,0±2,5	20,9±2,8	8,0±1,9
Number of cells studied	200	110	220	100	190	200	200	200

Note. A) bone marrow; B) blood lymphocytes.

bined with acetylcholine, 190 mg/kg; 2) monkey No. 3150 received serotonin in a dose of 40 mg/kg; 3) monkey No. 3276 received 5-methoxytryptamine, 25 mg/kg; 4) monkey No. 6172 received 5-methoxytryptamine, 20 mg/kg, together with 2-aminoethanethiol, 130 mg/kg.

All the animals were investigated 9 and 10 years after irradiation. The late mutagenic effect was assessed from the frequency and types of aberrant chromosomes in the bone marrow cells and peripheral blood lymphocytes. The bone marrow was treated by a method published previously [6, 8]. The culture of lymphocytes was obtained by the usual method [14].

EXPERIMENTAL RESULTS

The numerical indices of the chromosomes in the somatic cells of the irradiated monkeys (with or without chemical protection) did not differ significantly from those in the control (2n = 42). The percentage of euploid cells in the bone marrow of the irradiated monkeys was 90-94.77, compared with 93.25 in the control, and in the peripheral blood lymphocytes of the irradiated monkeys it was 89-94.5, compared with 95.77 in the control animals. Aneuploid sets of chromosomes in the cells of the irradiated monkeys, as in the unirradiated controls, were hypodiploid sets. The percentage of polyploid cells in the bone marrow of the irradiated monkeys receiving chemical protection was slightly but not significantly higher than in the group of animals not receiving chemical protection ($t = 0.6$). The numerical indices of the chromosomes in the late stages after irradiation in animals receiving radioprotectors thus agreed with the results of the irradiated and unirradiated controls.

Information on the number and types of chromosomal aberrations in the control and irradiated monkeys is given in Table 1.

As Table 1 shows, the level of chromosomal aberrations in the somatic cells of monkeys surviving irradiation with and without chemical protection was higher by an equal degree than the spontaneous changes in the chromosomes ($t = 4.0$-4.2). The number of chromosomal aberrations in the irradiated monkeys remained at the same high level with all types of chemical protection (Table 1). Differences in the frequency of chromosomal aberrations in the bone marrow cells and blood lymphocytes of the irradiated monkeys were not statistically significant ($t = 1.2$), except in one monkey (No. 6172). The main type of chromosomal aberrations following irradiation alone in that particular experiment, just as previously [6], and also in the monkeys receiving the chemical protectors, was symmetrical chromosomal exchanges. Acentric aberrations in irradiated monkeys, whether with or without protection, did not differ significantly from the control ($t = 1.6$). The frequency of pericentric inversions in the blood lymphocytes of monkeys receiving the radioprotectors, given an equal percentage of chromosomal aberrations, was a little lower than the frequency of symmetrical chromosomal translocations, but the differences again were not significant ($t = 1.9$). Attention is drawn to the fact that new clones of cells, with aberrant chromosomes as their markers, arise in the tissues of monkeys receiving radioprotectors, as well as after pure irradiation [6, 7]. The percentage of these similar changes did not exceed 7.5 in 100 cells studied.

The results can be summed up by saying that radioprotectors, while weakening the direct effects of irradiation [2-5, 9, 10], have no appreciable effect on the late consequences of irradiation and, in particular, they do not lead to any significant decrease in the level of structural mutations in chromosomes in the somatic cells of irradiated monkeys. Late radiation pathology is known to be based on nonlethal injuries to the genetic apparatus of the cell [1], and this evidently led to equalization of the late effect in monkeys surviving acute irradiation with or without protection by chemical compounds.

LITERATURE CITED

1. S. N. Aleksandrov, Vestn. Akad. Med. Nauk SSSR, No. 9, 11 (1965).
2. L. B. Berlin, Dokl. Akad. Nauk SSSR, No. 4, 998 (1970).
3. Z. A. Dzhemilev, L. D. Perepelkina, and M. G. Machavariani, Genetika, No. 9, 91 (1967).
4. N. P. Dubinin, M. A. Arsen'eva, and É. S. Kalyaeva, The Protective Effect of Cysteamine (β-Mercaptoethanolamine) on Chromosomal Aberrations in the Tissues of Monkeys and Mice [in Russian], Moscow (1960), p. 1.
5. L. G. Dubinina, Abstracts of Proceedings of the Eighth All-Union Congress of Roentgenologists and Radiologists [in Russian], Moscow (1964), p. 461.
6. L. P. Kosichenko, Genetika, No. 3, 105 (1972).
7. L. P. Kosichenko, Genetika, No. 12, 151 (1973).
8. D. S. Markaryan and M. G. Machavariani, in: Medical Primatology [in Russian], Tbilisi (1967), p. 136.
9. N. L. Shmakova, "Quantitative analysis of radiation damage and chemical protection of the bone marrow," Candidate's Dissertation, Moscow (1966).
10. S. P. Yarmonkenko, O. P. Ol'shevskaya, and N. L. Shmakova, Radiobiologiya, No. 1, 95 (1968).
11. M. A. Bender and P. C. Gooch, Radiat. Res., 18, 389 (1963).
12. A. B. Bloom, S. Neriahi, M. Kamada, et al., Lancet, 2, 672 (1966).
13. K. E. Buckton, P. A. Jacobs, K. Brown, et al., Lancet, 2, 676 (1962).
14. P. Moorhead, P. S. Nowell, W. Mellman, et al., Exp. Cell. Res., 20, 613 (1960).