Sustained mutagenic effect in bone marrow cells induced by signal nuclide ^{134}Cs retention in skeleton*

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Abstract The skeleton transference and the retention dynamics of *i.v.* ^{134}Cs are investigated. Results indicate that the retention percentage of ^{134}Cs in skeleton could be characterized by $R(t) = 0.0029\exp(-0.121t)$ with $T_{1/2}= 5.73$ d; the chromosome aberration percentage of somatic bone marrow cells increases obviously, the relationship between injected dose (X in kBq/g) and the chromosome aberration percentage can be expressed as $Y = 0.0561X^{0.427}$. It should be noted that sustained elevation of chromosomal aberration rates induced by ^{134}Cs can be upto the 47 th d.

Keywords Mutagenic effect, Bone marrow cells, Retention, ^{134}Cs, Skeleton, Mice

1 Introduction

^{134}Cs is a signal nuclide released by the accident of nuclear power plants, and one of the most important products in heavy nuclear fission. People are paying close attention to internal contamination of radiocesium to human health through ecological environment[1]. ^{134}Cs is easily absorbed into blood through various ways[2]. In recent years, with the continuous development of nuclear power plants and its wide scope of use in production and research fields, the number of persons contacting ^{134}Cs has been increasing constantly. It is worth noting that the sustained mutagenic effect of ^{134}Cs is closely related to its accumulative characteristics and there is no resolution yet. So, it is necessary to study the metabolic peculiarity of internal contamination of ^{134}Cs in skeleton as well as its sustained mutagenic effect on bone marrow cells.

2 Methods and results

2.1 Retention and absorption dose estimation of ^{134}Cs in skeleton

Experiments were carried out on 30 sexually mature BALB/c strain mice of 21±2 g. Animals were randomly divided into 6 experimental groups. Mice of experimental groups were given *i.v.* injection of 46.25 kBq/g ^{134}Cs in $^{134}Cs_2CO_3$. . Animals were sacrificed by decapitation through 10 h, 2, 6, 15, 30, and 47 d intervals. The left femora were immediately excised and put into a scintillation vial, their radioactivities were determined with an EKCO well type scintillation counter by the aid of NaI(Tl) crystal. Results show that the retention percentage of ^{134}Cs in skeleton falls gradually with the prolongation of observing time t in d (see Table 1). The retention of ^{134}Cs in skeleton can be characterized by

$$R(t) = 0.0029\exp(-0.121t)$$

and the half life $T_{1/2}$ in skeleton is 5.73 d.

From the cumulative radioactivities of ^{134}Cs in skeleton the cumulative absorption dose[3,4] can be calculated (see Table 1) and can be expressed as[5]:

$$D(r_k) = \sum_h A_h S(r_k \leftarrow r_h)$$

here D is dose of r_k in skeleton in mGy; A_h intake of radioactivities of r_h in whole body in kBq·d; S conversion factor of mGy/(kBq·d).

Table 1 Retention and absorption dose in skeleton after *i.v.* injection of 46.25 kBq/g ^{134}Cs

Time after injection	Number of mice	Retention/ kBq·g^{-1}	Dose/ mGy
10 h	5	4.71	3.98
2 d	5	2.34	15.00
6 d	5	1.17	40.50
15 d	5	0.34	85.90
30 d	5	0.04	130.49
47 d	5	0.02	156.00

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2.2 The sustained mutagenic effect in bone marrow cells induced by ^{134}Cs

Sexually mature male BALB/c strain mice of 21±2g were randomly divided into 7 groups as well as corresponding control group. Animals of experimental groups were given single i.v. injection of ^{134}Cs with 0.0093, 0.093, 0.93, 5.6, 9.25, 46.25 and 231.25 kBq/g, respectively; mice of control group, physiological saline. Internal contaminated mice were decaptitated after 24 h. Colchicine of 4 μg/g was injected i.p. 5.5 h before killed. Samples of femora were obtained quickly from the sacrificed animals, and put into 75 mmol/L KCl hypotonic solution. Then femora were broken to pieces by operation forceps. Bone marrow cells were collected and incubated at 37°C for 40 min in 75 mmol/L KCl hypotonic solution, then fixed, dispensed onto the slides and stained with Giemsa solution. Metaphase cells were analysed for chromosome aberrations.

Table 2 shows that there is a positive correlation between the chromosome aberration rates and the amount of intake of ^{134}Cs; as a whole, among the types of chromosome aberrations, chromatid breakage was predominate. The chromatid gap and exchange are shown in Fig.1.

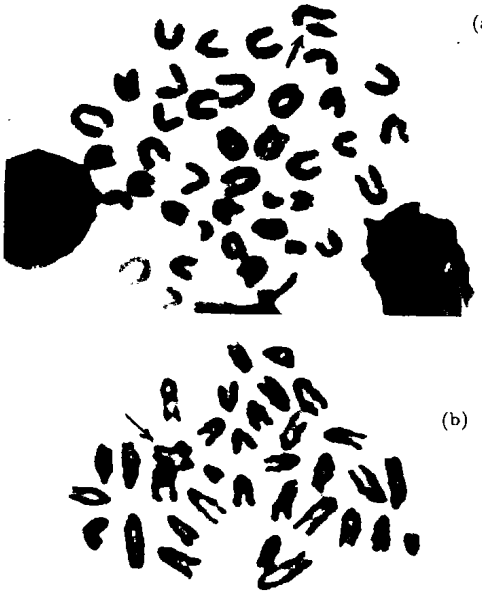

Fig.1 Chromatid gap (a) induced by *i.v.* 0.093 kBq/g ^{134}Cs and chromatid exchange (b) induced by *i.v.* 46.25 kBq/g ^{134}Cs in bone marrow cells

Table 2 Chromosome aberration percentage in bone marrow cells induced by i.v. ^{134}Cs

Radioactivity/ kBq·g^{-1}	No. of mice	No. of MPS	Chromatid aberration			Chromosome aberration		No. of AC	Abnormal percentage
			CMB	Gap	CME	CSB	Gap		
0	5	1000	1	1	0(0.20)	0	0(0)	2(0.20)	0.20±0.45
0.0093	5	1000	2	1	0(0.30)	0	0(0)	3(0.30)	0.30±0.45
0.093	5	1000	8	2	0(1.00)*	0	0(0)	10(1.00)	1.00±0.71*
0.93	5	1000	10	2	0(1.20)*	0	0(0)	12(1.20)	1.20±0.67*
5.6	5	1000	16	5	0(2.10)**	0	0(0)	17(1.70)	2.10±1.08**
9.25	6	1200	22	2	1(2.08)**	3	0(0.25)	24(2.00)	2.33±0.75**
46.25	5	1000	29	13	1(4.30)**	3	1(0.40)	46(4.60)	4.70±0.45**
231.25	5	675	91	7	1(14.67)**	1	0(0.15)	85(12.59)	14.82±3.98**

Notes: In Tables 2 and 3, $^{*}P < 0.05$, $^{**}P < 0.01$; MPS—Metaphase scored, CMB—Chromatid breakage, CME—Chromatid exchange, CSB—Chromosome breakage, AC—Abnormal cells; Data in parentheses express the corresponding aberration percentage

The relationship between injected dose (X in kBq/g) of ^{134}Cs and chromosome aberration percentage in bone marrow cells can be expressed as

$$Y = 0.0561X^{0.427}$$

Animals were randomly divided into 6 experimental groups and corresponding control groups. Mice of experimental groups were given i.v. injection of 46.25 kBq/g ^{134}Cs. Then through 10 h, 2, 6, 15, 30, and 47 d intervals animals were decapitated. Samples of femora were obtained and chromosome specimens were made with the aforementioned method.

Metaphase cells were analysed for chromo-

some aberrations. Table 3 indicates that chromosome aberration percentages are elevated significantly only after 10 h injection of ^{134}Cs. Among the types of induced chromosome aberrations, chromatid breakage is predominant in company with few chromosome breakage and microbodies. It should be noted that chromosome aberration percentages were still at high level up to 47 d.

Table 3 Sustained aberration percentages of chromosomes in bone marrow cells induced by *i.v.* 46.25 kBq/g ^{134}Cs

Time after *i.v.*	No. of mice	No. of MPS	Chromatid aberration		Chromosome aberration			Abnormal percentages
			CMB	Gap	CSB	Gap	Microbody	
Control	5	1000	1	1(0.2)	0	0	0(0)	0.20±0.45
10 h	5	1000	31	8(3.9)	2	0	0(0.2)	4.10±1.34**
2 d	5	1000	26	4(3.0)	2	0	0(0.2)	3.20±0.76**
6 d	5	1000	23	3(2.6)	3	0	1(0.4)	3.00±0.61**
15 d	5	1000	15	5(2.0)	1	0	0(0.1)	2.10±0.89**
30 d	5	1000	28	3(3.1)	0	0	0(0)	3.10±1.34**
47 d	3	600	7	1(1.3)	0	0	0(0)	1.33±0.29**

3 Discussion

The specific property of action for radionuclides in the body is closely related to its selective transportation and retention in tissues, and has the intimate relationship with mechanism of its action [6]. Therefore, the dynamic course of transportation and retention by ^{134}Cs internal contamination determined its dose distribution in tissues. So, the dynamic law of ^{134}Cs internal contamination was the basis of explaining the action of ^{134}Cs in organism.

Our study[7] shows that the chromosome aberration rates in bone marrow cells induced by ^{134}Cs are significantly higher than that in spermatogonia; the somatic cells are more sensitive to ^{134}Cs than reproductive cells. Present experimental results indicate that the main type of the chromosome aberrations in bone marrow cells induced by ^{134}Cs internal contamination was chromatid breakage; this is related to the cell cycle and the types of the chromosome aberrations induced by radiation. The hemopoietic cells in bone marrow are in continued differentiation and reproduction stage, and more cells are in S-period and G_2-one[8]. These cells suffer internal contamination, and show chromatid breakage in the metaphase of cell division[9,10].

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