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INFLUENCE OF LOW TEMPERATURE ON THE EXCRETION OF RADIOCESIUM AND RADIORUTHENIUM COMPARED WITH RADIOSTRONTIUM

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Abstract

The excretion rates for ^{137}Cs and ^{106}Ru after an internal contamination of CBA-mice were compared with that of ^{85}Sr. The enhancing effect caused by 'low-temperature treatment' (+4°C) observed in the case of radiostrontium was still more obvious for radiocesium but did not occur in animals contaminated with radioruthenium.

Key words: Radiobiology; excretion rate, mice, ^{85}Sr, ^{137}Cs, ^{106}Ru, low temperature.

A great number of investigations have been made concerning the problems of releasing nuclides which have been incorporated into the organism of vertebrates. Radiostrontium especially has been seriously looked upon due to the hazards of radiation damage attached to that nuclide.

In 1958 Mefferd et al. (3) showed that rats, statistically, had an increased urinary excretion of calcium after chronic exposure to cold. The close chemical relationship between calcium and strontium led us to undertake further studies in mice (8, 9), showing that animals excreted also radiostrontium (^{85}Sr) more rapidly after exposure to cold. It was also evident that a successively decreasing room temperature, from +9 to +4°C, caused a still more intense excretion rate. Even if the animals were placed into the lower temperature after they had spent the first 24 h following the strontium administration in room temperature (+24°), they showed an increased excretion rate when the temperature was lowered.

Both radiocesium and radioruthenium have been shown by Nelson et al., 1961 and 1962 respectively, to have a completely different autoradiographic distribution compared to ^{90}Sr. This made it interesting to study whether or not these nuclides, by comparison with radiostrontium and in spite of their different localization, could be influenced by a lower environmental temperature as a possible way to accelerate excretion after an accidental nuclide intake.

Material and Methods

Adult mice were intraperitoneally injected with one of three nuclide solutions. Details are shown in the following schedule:

Nuclide	Mouse strain (and age in days)	Administered to each animal: Volume of solution	Administered to each animal: Activity of nuclide
^{137}Cs	CBA ♂	0.1 ml	15 kBq
^{85}Sr	CBA ♂	0.1 ml	37 kBq
^{106}Ru	C57/B1 ♂ (~75 d)	0.2 ml	12 kBq

Immediately after the injection (within 5 min) the animals were measured by whole body counting in a 'small animal counter', consisting of a plastic chrystal detector. The animal, in a plastic box, was lowered into a cylindrical well about 70 mm in diameter. The whole detector was covered by iron bars as a shield against external radiation. The results of the measurements at different intervals after the injections were expressed in percentage of the initial measurement for each animal. The means and standard errors were calculated from these individual values. In the case of ^{85}Sr the results were corrected for

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Table 1

Retention in percentage of initial measurement

Nuclide	Days after administration	Normal room temp. (+24°C) Mean ± SE	Low room temp. (+4°C) Mean ± SE	t-value: normal/low temp. and level of signific.
		n=14	n=25	
^{137}Cs	1	60.1±2.0	50.8±1.2	3.987***
	2	47.6±1.7	39.8±0.9	4.055***
	3	37.9±1.4	30.1±0.8	4.838***
	4	32.3±1.2	24.8±0.7	5.399***
	7	21.6±0.8	15.7±0.4	6.596***
	9	16.4±0.6	11.2±0.3	7.752***
	11	12.6±0.4	8.5±0.3	8.200***
	15	7.7±0.3	4.7±0.1	9.487***
	18	6.0±0.2	3.3±0.1	12.07 ***
	22	3.9±0.2	2.0±0.1	8.497***
	29	1.9±0.1	0.9±0.1	7.071***
		n=10	n=10	
^{85}Sr	1	64.9±2.1	48.9±2.4	5.017***
	2	52.8±1.1	41.4±2.2	4.635***
	3	47.2±1.5	35.5±1.9	4.833***
	7	42.1±0.7	30.2±1.5	7.189***
	9	40.2±0.9	28.6±1.4	6.970***
	14	36.7±0.8	27.4±1.3	6.093***
	21	33.4±0.6	24.4±0.9	8.321***
	25	32.6±0.8	22.9±1.1	7.132***
	30	30.3±0.8	20.4±1.0	7.731***
		n=10	n=10	
^{106}Ru	1	84.4±1.7	75.5±3.2	2.456*
	2	77.3±2.0	70.1±2.9	2.044
	5	59.9±1.7	55.8±2.9	1.220
	7	49.4±1.9	46.2±2.0	1.160
	9	44.6±1.0	40.0±1.9	2.142*
	13	36.2±0.7	34.3±1.5	1.148
	21	29.7±0.5	28.6±1.6	0.656
	28	23.8±0.5	22.9±1.7	0.508
	60	14.5±0.4	14.3±0.8	0.224

*** $p<0.001$, ** $0.001<p<0.01$, * $0.01<p<0.05$.

decay ($T_{1/2}$ 67 days). For ^{137}Cs and ^{106}Ru no such corrections were necessary, because of their half-lives of 30 years and 365 days respectively.

In each nuclide group one part of the animals (the controls) remained in normal room temperature, +24°C, whereas the other part was taken into a low temperature area at +4°C.

Results

The results of the measurements of the retained amount of the nuclide are shown in Table 1 and Fig. 1. It is evident that the ^{137}Cs excretion rate in the control animals kept at +24° was remarkably higher than the ^{85}Sr and ^{106}Ra excretion rates. It was also obvious than the 'low temperature treatment' significantly affected the animals contaminated with ^{137}Cs and ^{85}Sr, whereas animals contaminated with ^{106}Ru did not show a similar response to low temperature. In fact the excretion rates of the two temperatures investigated were almost identical.

Discussion

In earlier investigations (9), the retention of radiostrontium was studied in mice transferred to low temperature immediately after the administration of the nuclide as well as in those transferred 3 or 7 days later. The effect of an immediate onset of cold was quite obvious, while animals taken into the lower temperature later did not show an excretion rate of the same magnitude. In autoradiograms the amount of radiostrontium in soft tissues has been shown to be of lesser magnitude and to have subsided more rapidly with no persistent accumulation, especially when compared with that of the skeleton (7).

The decreased strontium retention in animals subjected to a low environmental temperature could, according to a

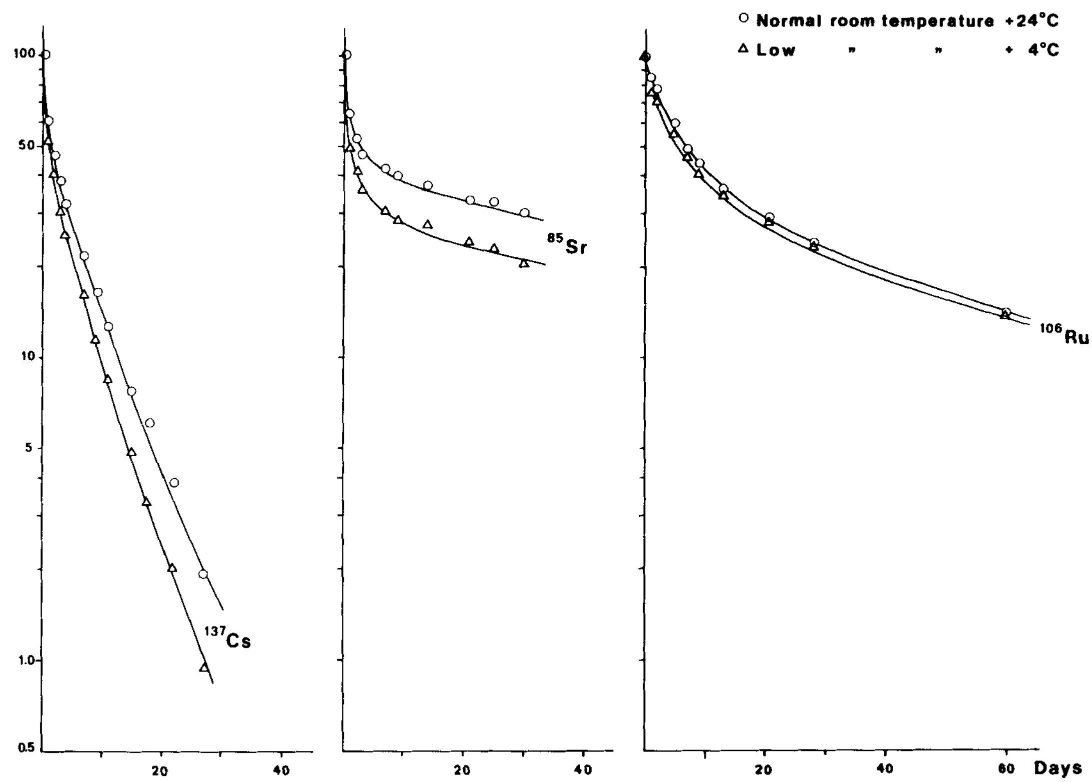

Fig. 1. Retention of ^{137}Cs, ^{85}Sr and ^{106}Ru respectively, measured at different intervals after the administration and given in percentage of the initial measurement (performed within 5 min). See also Table 1.

hypothesis of a decalcification process, triggered by cold, presumably be attached to a decrease in the weight of the skeleton parts of the animals in the low temperature groups. Four different parts of the skeleton (femur, tibia, humerus and sacral vert.) have previously been investigated from that point of view and the results do not seem to contradict this hypothesis (9). Similar effects on the radiostrontium excretion have partly been observed after administration of non-radioactive Sr-salts ($SrCl_2$) to the contaminated animals almost simultaneously with the radionuclide (4). On the other hand, agents like mechanical trauma, e.g., were not successful in diminishing the nuclide retention.

Radiocesium, on the contrary, is preferably accumulated in the cartilage, especially the hyaline type and in skeleton muscles as shown in autoradiographic studies (5). The nuclide, like potassium, is taken up by the soft tissues against the concentration gradient (2), which is generally attributed to an intracellular accumulation. The radiocesium has also been observed to be taken up more readily by physiologically active than by inactive muscles (1). The rapid uptake reported in the cartilage is astonishing with regard to the absence of blood vessels in that tissue and does not suggest accumulation due to incorporation into an organic compound.

The exposure to low temperature now revealed that the excretion of the nuclide was significantly accelerated, probably depending on the way of accumulation. This reflects a higher metabolic activity in the tissues initiated by the cold environment. Three weeks after the contamination the Cs-retention in the low-temperature treated animals was between 50 and 55% of the control figure, compared with 70–75% in the case of radiostrontium.

The third nuclide investigated, radioruthenium, was highly concentrated in connective tissue, e.g. in the blood vessels, fascia, intestinal submucosa and the subcutis (6). The retention of ruthenium in the connective tissues was initially followed up for 32 days without any signs of redistribution. The measurement in the present study was extended to 60 days, and the comparison between control animals in normal room temperature and animals in +4°C showed clearly that ruthenium was not affected by the biological factors associated with the cold induced phenomena. One explanation could be that ^{106}Ru easily forms colloids at injection and is rapidly phagocytized and fixed in the RES-system. Equilibrium is therefore reached very soon and, in accordance with the present study, no difference is to be found between animals in the two temperature groups.

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