The Effect of Potassium, Lactose and Thyroxine Administration on Radiocesium Retention in Young Rat

INABA*, Jiro, MATSUSAKA**, Naonori and Ryushi ICHIKAWA*

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ABSTRACT

Some factors affecting on $^{137}$Cs retention in young rats were investigated to study the characteristic features in the metabolism of the nuclide in the rats of early stage of growth. Supplement of potassium accelerated $^{137}$Cs removal from sucklings but slightly from weanlings. Weanling rats fed on lactose-supplemented diet showed somewhat higher retention of the nuclide than that in the control rats. Daily administration of thyroxine to suckling rats increased removal of body $^{137}$Cs. However, this effect began to appear about ten to twelve days after the beginning of the administration of thyroxine in the case of 7-day-old sucklings (age at the beginning of experiment), whereas it appeared within a few days in the case of 17 day-old ones.

INTRODUCTION

The rate of the internal exposure of infants or children to radiation should be different from that of adult even under the same intake level of radionuclides because of the age dependency of metabolism of radionuclides. It is our present purpose to study the characteristic features of the metabolism of cesium in the very young stage of experimental animals.

In our previous investigations1-3, much higher retention of $^{137}$Cs and $^{86}$Rb was observed in suckling rats and mice than in weanlings. Furthermore, it was recently observed4) that rats fed on their mother's milk still after normal weaning age...
kept their body $^{137}\text{Cs}$ considerably higher than normally weaned rats of the same age. This fact indicates that dietary factor should be one of the most important factors associated with the high retention of $^{137}\text{Cs}$ in suckling rats.

For these reasons, the present investigation deals with the influence of potassium, lactose and thyroxine on the whole body retention of $^{137}\text{Cs}$ in the suckling and weanling rats.

MATERIALS AND METHODS

A litter (ten or twelve individuals) of Wistar strain albino rat was divided into control and treated group of pups, which were orally administered, as a single dose, 0.5 $\mu\text{Ci}$ of $^{137}\text{CsCl}$ in 0.1 m/ of 0.9% saline solution (pH around 6) by a stomach tube three or four days prior to the beginning of each experiment. One or two pups in each group were not administered $^{137}\text{Cs}$ in order to serve as the index for "background" level of $^{137}\text{Cs}$ due to the cross contamination by mother's milk and by mutual contact. It is known that mother rats often lick the urine and feces of their pups resulting in some amount of $^{137}\text{Cs}$ supply to their pups. This contribution can be subtracted by using the "background" pups. A small animal counter (Armac, model 446) was used for the whole body measurement of the rat pups.

RESULTS

Effect of administration of KCl on whole-body retention of $^{137}\text{Cs}$

As potassium content in a commercial diet is fairly higher than in rat's milk, difference of the potassium content between rat's milk and the commercial diet is considered to be one of the most important factors which may contribute to the difference of turn-over rate of $^{137}\text{Cs}$ between suckling and weanling rats.

Two experiments were performed to observe the effect of administration of potassium chloride on retention of $^{137}\text{Cs}$ in young rats. Firstly, two-day-old rats were given $^{137}\text{Cs}$ orally. Next day, their whole-body radioactivities were determined and the litter was divided into two groups. Treated group was given KCl solution by a stomach tube as much as 1 mg KCl in 0.02 ml of saline solution per 1 g body weight every day, while control group was given only saline solution of the same amount. Their whole-body radioactivity and body weight were measured periodically. Secondly, the same experimental procedure was applied for 21-day-old weanlings in order to compare the effect of KCl administration in them with that in suckling rats.

Fig. 1 illustrates the effect of administration of KCl on the whole-body retention of $^{137}\text{Cs}$ in the suckling and weanling rats. Administration of KCl accelerates removal of $^{137}\text{Cs}$ from the suckling rats obviously. Biological half-lives of $^{137}\text{Cs}$ were 8.8 days for the control group and 6.6 days for the treated group. In the case of weanlings, however, the effect of KCl was not very significant. Biological half-life for the control group was 3.1 days while that of the treated group was 2.8 days.
Considering the fact that potassium administration reduces the biological half-life of cesium for suckling rats to a considerable extent but to much less extent for weanling rats, it may be reasonably assumed that low potassium content in rat's milk is one of the most important factors for the slower removal of cesium in suckling than in weanling rats.

Effect of lactose administration on wholebody retention of $^{137}$Cs

Since lactose is one of the important constituents of milk and not contained in the commercial solid diet, the authors paid special attention to lactose as one of the factors influencing the retention of $^{137}$Cs in suckling rats.

On the 21st day after birth, a litter of weanlings which were given once $^{137}$Cs several days before were divided into two groups. Treated group was fed on a powdered diet which was supplemented with lactose at 20% in weight, whereas control group was fed on the usual commercial diet alone which did not contain any lactose. A small amount of water was added to the powdered diet and mixed well in order to give moisture. Thereafter both group were measured for their whole-body radioactivity and body weight periodically.

The result of the experiment on the effect of lactose on the whole-body retention of $^{137}$Cs in weanlings is graphically represented in Fig. 2. The result shows that the lactose supplement makes the whole-body retention of $^{137}$Cs fairly larger. Biological half-life of $^{137}$Cs for the treated group was 3.9 days, while that for the control

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**Fig. 1.** Retention of $^{137}$Cs in suckling and weanling rats which were daily administered KCl solution. $^{137}$Cs retention is expressed as percentage of initial whole-body burden at the beginning of the experiment.

**Fig. 2.** Retention of $^{137}$Cs in weanling rats which were fed on lactose-supplemented diet. $^{137}$Cs retention is expressed as percentage of initial whole-body burden at the beginning of the experiment.
group, 2.5 days. In this experiment, some of the treated group revealed symptoms of diarrhea and the increment of body weight in the treated group was slightly lower than in the control group. However, it was unlikely that these introduced any substantial effect.

Effect of thyroxine administration on whole-body retention of $^{137}$Cs

It has been reported that turnover rate of $^{137}$Cs is related to the rate of thyroxine secretion and it has also been reported that thyroxine secretion rate is rather low in new-born rats. Therefore, the effect of thyroxine administration on the retention of $^{137}$Cs in suckling rats was examined.

Seven-day-old sucklings, which were administered with $^{137}$Cs several days before, were determined for their whole-body radioactivity and were divided into two groups. Thereafter, treated group was administered orally by a stomach tube with L-thyroxine as sodium salt suspended in saline solution every day as much as 1 μg per gram of body weight, while the control group was given only saline solution of the same amount. The radioactivity of $^{137}$Cs in the whole-body and their body weight were determined periodically. The same experimental procedure also applied for 17-day-old rats.

Effect of the administration of thyroxine on the whole-body retention of $^{137}$Cs in the rats of two different ages are shown in Figs. 3 and 4, respectively. As seen

![Graph](image-url)

**Fig. 3.** Retention of $^{137}$Cs in young rats which were daily administered L-thyroxine (Seven-day-old at the beginning of the experiment). $^{137}$Cs retention is expressed as percentage of initial whole-body burden at the beginning of the experiment.
in Fig. 3, in the case of 7-day-old sucklings, it was recognized that the effect was not so significant for about first 10 days after the administration of thyroxine. After 10 days, i.e. on the 17th day after the birth, the effect of the daily administration of thyroxine first fairly significantly appeared as an enhancement of $^{137}$Cs excretion. On the contrary, in the case of 17-day-old rats the effect of thyroxine appeared much earlier than the above case as shown in Fig. 4. It is of great interest that the effect of daily administration of thyroxine first appeared about 17 days after birth for both 7-day-old and 17-day-old rats. In these experiments, there was no significant difference in the body weight between the treated and control groups, but it was observed that sucklings of the treated group opened their eyes one day earlier than those of the control group.

Fig. 4. Retention of $^{137}$Cs in young rats which were daily administered L-thyroxine (Seventeen-day-old at the beginning of the experiment). $^{137}$Cs retention is expressed as percentage of initial whole-body burden at the beginning of the experiment.

DISCUSSION

Difference of chemical composition between milk and the commercial diet may be a very important factor associated with higher retention of $^{137}$Cs in suckling than in weanling rats as reported previously. Unfortunately, there are few quantitative data available on the chemical constituents of rat's milk. However, Luckey et al reported that the content of potassium in rat's milk is nearly 0.1% as wet basis. On the contrary in the commercial diet, potassium is contained as much as 0.7%. From these values and the amount of food taken daily, it is reasonably estimated that a pup fed on the commercial diet takes potassium about 5 to 10 times more per unit body weight than a pup on the breast milk of rat. It is well known that the rats fed on potassium deficient diet have a much longer biological half-life of cesium. It is also known that the supplement of potassium to normal diet have no significant effect on the cesium retention. From these facts, the present authors assume that there may be a certain size of potassium pool in the body and when the pool is filled, cesium behaves in its own way being affected by many factors other than potassium. When the pool is not filled, the behavior of cesium is strongly affected by potassium. In the case of control suck-
ing rats, the pool may not be filled sufficiently and their retention of cesium is much higher than the potassium-supplemented sucklings, the pool of which are being filled. On the other hand, in the case of weanlings, the pool of both control and treated groups may be filled and hence the difference of cesium retention between them is rather ambiguous even if potassium is added to the diet for treated rats.

As to the effect of lactose we have no speculation for the physiological mechanism. However, the effect of lactose observed here is consistent at least qualitatively with the special high retention pattern of $^{137}$Cs in suckling rats. There should be more works to be investigated.

Lengemann has shown that low environmental temperature increased turn-over of cesium in the body and that the temperature effect on cesium metabolism was largely caused from the state of thyroid function$^{10}$. On the other hand, Beltz and Reineke showed by investigating the thyroid secretion rate in the neonatal rats$^6$, that the neonatal rats had low level thyroid function at birth, and that this condition persisted until the animal weighed 22 grams. From these knowledge, the present authors assumed that the low turnover rate of cesium in the neonatal rats might be caused at least partly by their low level thyroidal function. The results obtained in the present investigation show that the effect of thyroxine administration is rather small before the rat becomes 17-day-old. After that, when the weanlings began to eat some amount of the commercial solid diet in addition to the breast milk, the effect becomes more and more significant with time. From these observations, it is considered that thyroxine accelerates the turnover rate of $^{137}$Cs, but when potassium level in food is low, i.e. when the potassium pool is not filled, the behaviour of cesium in the body is beyond the effect of thyroxine.

It may be concluded that the higher retention pattern of $^{137}$Cs in suckling rats than in weanlings is associated primarily with the low level potassium in the rat milk, namely, non-filled potassium pool and secondarily with the whole-body metabolic rate which can be accelerated by thyroxine and other factors.

REFERENCES

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