Organ Distribution of ^{137}Cs in Mouse Fetuses and Their Dams

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Received November 25, 1996

A single dose of ^{137}Cs was given intravenously to pregnant mice on day 17 of gestation, and organ distribution of this nuclide in mouse fetuses and their dams was studied by measuring radioactivity and by macroautoradiography. Fetal uptake of ^{137}Cs was 0.8% of the initial dose 24 h after administration; about 11% of the initial dose was incorporated in litter during the same period. Concentrations of ^{137}Cs in fetal organs were 0.4–0.8%/g 24 h after administration, whereas concentrations in dams' organs were in a range of 2–6%/g. Therefore, concentrations in maternal organs such as liver, spleen, kidneys and muscle were 4–6 times higher than those in fetuses. Among the maternal organs, the salivary gland represented the highest concentration of 25%/g 1 h after administration to 6.4%/g 24 h after administration. This remarkable uptake in the salivary gland should be emphasized because of its close location to the thyroid gland in experimental animals and humans. Macroautoradiograms supported the findings obtained by measuring radioactivity in the organs. Macroautoradiograms in color may facilitate visual understanding of organ distribution of this nuclide.

Key Words: cesium-137, organ distribution, mouse fetus, dam,
salivary gland, pregnancy

1. Introduction

^{137}Cs is produced by nuclear fission of uranium and plutonium. In the 1950–60s, the biosphere was widely contaminated with this nuclide due to nuclear tests in the atmosphere¹⁾. In addition, the Chernobyl reactor accident in 1986 released a tremendous amount of ^{137}Cs into the environment, and induced serious contamination of food and physical beings worldwide²⁾. It is well known that ^{137}Cs is a hazardous radioactive nuclide among fission products since it is almost completely absorbed from the gastrointestinal tract, emits gamma rays with high energy (662 keV from its daughter nuclide $^{137\text{m}}\text{Ba}$) and most of it is incorpo-

rated in soft tissues. Therefore, a number of investigators have studied on metabolism and organ distribution of this nuclide^{3)–6)}.

Moreover, ^{137}Cs is easily transferred to fetuses through the placenta in experimental animals, when pregnant dams ingest this nuclide^{7),8)}. It was revealed that the fetal uptake of ^{137}Cs markedly increased with the advance of gestational age⁸⁾, but only a few information is available on fetal organ distribution of this nuclide⁹⁾. This study investigated organ distribution of ^{137}Cs in mouse fetuses and their dams by measuring radioactivity and by macroautoradiography.

2. Materials and Methods

2.1 Experiment 1 (Organ distribution of ^{137}Cs in mouse fetuses and their dams)

Adult ICR female mice, 11–14 weeks of age, were mated overnight, and the day of gestation was regarded as day 0 when a vaginal plug was present. These mice were maintained on a pelleted diet (MF : Oriental Yeast Co., Ltd., Tokyo) and housed in an air-conditioned room at 23–25°C.

Radioactive ^{137}Cs chloride (carrier free) in 0.5 mol/l HCl solution was obtained from Amersham, U. K., and was diluted with saline to a concentration of 2 MBq/ml (pH 5). Twenty pregnant mice were injected intravenously with a single dose of 0.05 ml (100 kBq) of ^{137}Cs solution on day 17 of gestation, and radioactivity was measured immediately after administration in all animals. These pregnant mice were equally divided into four groups, which were respectively killed under ether anesthesia 1, 3, 6 and 24 h after administration. The fetuses were then removed for radioactivity measurement. From these fetuses, liver, spleen, kidneys and muscle were placed in separate polyethylene test tubes. The dam's organs including the liver, spleen, kidneys and muscle, and also the placenta and fetal membranes were dissected and treated in the same manner. Radioactivity in these samples was measured using a well-type scintillation counter with an NaI(Tl) crystal (ARC-300 : Aloka, Co., Ltd., Tokyo).

The amounts of ^{137}Cs incorporated and its concentration in these samples were expressed as percentages of the administered dose and percentages of the administered dose per gram of tissue, respectively.

2.2 Experiment 2 (Observation of the organ distribution of ^{137}Cs in mouse fetuses and

dams by macroautoradiography)

Two pregnant ICR mice on day 17 of gestation were injected intravenously with a single dose of 200 kBq ^{137}Cs in 0.1 ml. A macroautoradiographic technique¹⁰⁾ was used to observe the organ distribution of ^{137}Cs in mouse fetuses and dams. Each mouse was killed with ether inhalation 1 and 24 h after ^{137}Cs administration. A paste of carboxymethyl cellulose was applied to the body surface of these mice after clipping their hair. Then, the mice were rapidly frozen in a mixture of acetone and solid carbon dioxide. A 40 μm thick section was cut on a microtome (Type 1111 : Yamato Koki Co., Ltd., Tokyo) and placed on a piece of adhesive tape (MAG Tape : Nakagawa Chemical Co., Ltd., Tokyo). The section on adhesive tape was freeze-dried at -20°C for one week. After the section was dried, its surface was covered with a polyester film 6 μm thick (Lumirror : Toray Industries Incorporation, Tokyo) to avoid chemical fog, attached to an X-ray film (RX-new : Fuji

Fig. 1 Uptake of ^{137}Cs in the mouse fetus, placenta and fetal membranes after a single intravenous injection of ^{137}Cs to pregnant mice on day 17 of gestation (mean of 5 litters $\pm$ S.D.).

Fig. 2 Changes in ^{137}Cs concentration in fetal (a) and dams' organs (b) on day 17 of gestation after a single intravenous injection of ^{137}Cs .

(a) : mean of five litters $\pm$ S.D., (b) : mean of five dams $\pm$ S.D.

Photo Industrial Co., Ltd., Tokyo) in a cassette and kept in a cool darkroom for 2 weeks. The X-ray film was then developed in the conventional manner and macroautoradiograms were made. These black and white macroautoradiograms were scanned by an image scanner to convert the images to color.

3. Results and Discussion

As shown in Fig. 1, the fetus incorporated 0.14% of the initial dose 1 h after administration, which was followed by 0.8% of the initial dose 24 h after administration. This fetal uptake pattern was in good agreement with data already reported⁸⁾. As the mean litter size was 14, the amount incorporated per litter was estimated to be about 11% of the initial dose 24 h after administration. On the other hand, the placenta contained about 0.2% of the initial dose 1 h after

administration, and then decreased to 0.1% of the initial dose 24 h after administration. The fetal membranes incorporated much less ^{137}Cs than these two structures. Such a rapid transfer of ^{137}Cs from dam to fetus and an increasing tendency of the fetal uptake of this nuclide have been demonstrated in the rat⁷⁾.

In addition, changes in concentrations of ^{137}Cs in the fetal liver, spleen, kidneys and femoral muscle were presented in Fig. 2a, together with a whole fetus. The concentration among fetal organs examined was in a similar range (0.4–0.8 %/g) 24 h after administration, whereas in the dams concentration ranged from 2 %/g to 6 %/g 24 h after administration (Fig. 2b). Twenty-four hour after administration, concentrations in the organs significantly differed between fetuses and dams, i.e. concentrations in the maternal soft tissues were about 4–6 times higher than those in

Fig. 3 Autoradiogram showing the distribution of ^{137}Cs in a pregnant mouse on day 17 of gestation 1 h after administration.

(a) : sagittal section , (b) : sagittal section of the left side. Concentration of ^{137}Cs from high to low is represented in color as follows : white (highest), red, yellow, green, blue, purple and black in order.

Fig. 4 Autoradiogram showing the distribution of ^{137}Cs in a pregnant mouse on day 17 of gestation 24 h after administration (sagittal section).

Concentrations of ^{137}Cs are represented by the same color scheme as in Fig. 3.

the fetuses. Among maternal organs, salivary gland and kidneys showed the highest concentration of 6.4 %/g and 4.7 %/g, respectively, even 24 h after administration. Such high accumulation in the salivary gland was previously demonstrated in rats¹¹⁾, but little attention has been paid to this phenomenon. Although ^{137}Cs is usually assumed to be distributed uniformly throughout the body¹⁾, remarkable uptake in the salivary gland

should be emphasized because of its close location to the thyroid gland in experimental animals and humans.

The macroautoradiograms obtained in Experiment 2 revealed that ^{137}Cs was heavily deposited in the salivary gland and kidneys of the dams 1 h after a single intravenous administration (Figs. 3a and 3b). This finding supported data obtained by radioactivity measurement in Experiment 1. In the kidneys, a higher concentration was observed in the medulla compared to that in the cortex (Fig. 3b). The salivary gland, kidneys and skeletal muscles still had rather high concentrations 24 h after administration (Fig. 4). However, fetal uptake was low 1 h after administration, but uptake increased with time (Figs. 3a, 3b and 4). Even so, concentrations in these fetal tissues did not exceed those in the dams. Macroautoradiograms in color may facilitate visual understanding of the organ distribution of this nuclide.

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要 旨

マウス胎子および母体における ^{137}Cs の臓器分布

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妊娠 17 日目のマウスに ^{137}Cs を 1 回静脈内に投与した後, 胎子および母体臓器における ^{137}Cs の取込みを放射線測定およびマクロオートラジオグラフィによって調べた。投与後 24 時間目の胎子 1 匹あたりにおける取込み量は投与量の 0.8% で, 1 腹あたりに換算すると投与量の 11% となった。さらに, 投与後 24 時間目における胎子各臓器の ^{137}Cs 濃度は 0.4-0.8 %/g であったのに対し, 母体各臓器の濃度は 2-6 %/g であり, 母体臓器における濃度のほうが胎子臓器の濃度よりも 4-6 倍ほど高くなった。特に, 母体の器官のなかでも唾液腺が最も高い濃度を示し, 投与後 1 時間目および 24 時間目では, それぞれ 25 %/g および 6.4 %/g となった。唾液腺は甲状腺に近接して存在しているので, 唾液腺における ^{137}Cs の顕著な取込みについて注目する必要がある。マクロオートラジオグラムの所見は, 放射線測定によって得られた結果を支持するものであり, カラーで示された像是 ^{137}Cs の臓器分布を視覚的に捉えるのに役立つ。