TRANSFERENCE AND ACCUMULATIVE PECULIARITY OF ENRICHED URANIUM IN ORGANISM*

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ABSTRACT

Studies show that $^{235}UO_2F_2$ was chiefly localized in kidneys, then in skeleton and liver. Its radioactivity in skeleton rose steadily while the concentration in kidneys and liver droped. $^{235}UO_2F_2$ was difficult to pass through the blood- testes barrier. With 1 to 6 h contact period, only 1.4- 1.6 % $^{235}UO_2F_2$ was found in the intact skin, but 41—54 % in the abrasive skin. The dynamic retention of $^{235}UO_2F_2$ through intact or abrasive skins was also dominantly localized in kidneys, skeleton and liver. Accumulation of insoluble $^{235}U_3O_8$ in gastrointestinal tract was well described by a double- exponential- term expression. Values of retention were estimated for fast component $T_1 = 0.34$ d, and for relatively long term component $T_2 = 4.05$ d.

Keywords: Transference Accumulation Enriched uranium Intact skin Abrasive skin Testes

1 INTRODUCTION

Enriched uranium is one of the main nuclear fuels for nuclear power stations[1]. In the enrichment process uranium hexafluoride is used to enrich uranium but easily forms uranyl fluoride when it leaks out into ambient air and meets with moisture[2]. If it is once formed, uranyl fluoride is most likely to enter the worker's body on the spot. Moreover, now in the sphere of radiation medicine what is concerned about the environmental pollution and damage to human beings by nuclear fuel and its fission products released by nuclear tests and plants. Especially in recent years nuclear power plants are built continually, therefore, observations of its effect on environment and in the body become a significant task. Its action and injury effect in the body showed a close relation on retentive peculiarity of enriched uranium. So we paid attention to its metabolic peculiarity in organism.

2 EXPERIMENTAL METHODS AND RESULTS

2.1 Transference and accumulative peculiarity of enriched uranium in rats

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2.1.1 The retention of $^{235}UO_2F_2$ in different organs

Uranyl fluoride containing ^{235}U of 18.9% (60 mg/ml) was used in this study. Experiments were carried out on 34 male Wistar strain rats of 188± 12 g. The transference and accumulative peculiarity of $^{235}UO_2F_2$ were observed either after iv once 20 mg/kg or after consecutive 3 d ip 15 mg/(kg · d). Rats were decapitation- killed after different periods of $^{235}UO_2F_2$ action. Tissue samples of kidney, skeleton and liver were obtained from the sacrificed animals. Each sample of 100 mg was prepared homogeneous clarity solution by adding 0.2 ml $HClO_4$ and 0.4 ml 30 % H_2O_2 in a scintilation vial, then put in the water bath at 80 °C for 1 h, after cold, adding 5 ml ethylene glycol ether[3]. At last 8 ml of scintillation mixture, consisting of 100 % toluene, 0.6 % PPO, was added. Radioactivities of tissue samples were determined by liquid scintillation counting with the aid of a Beckman LS 6800.

As shown in Fig.1 and 2, the dynamic retention of radioactivity in the body showed that $^{235}UO_2F_2$ was chiefly localized in kidneys, then in skeleton and liver. It should be noted that the radioactivity of $^{235}UO_2F_2$ in skeleton rose steadily while the concentration in kidney and liver droped.

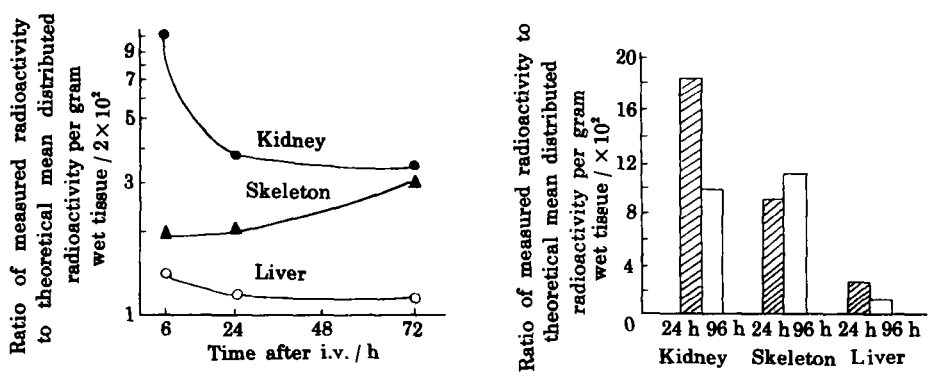

Fig.1,2 Comparative retention in kidneys, skeleton and liver after iv $^{235}UO_2F_2$ 20 mg/kg (1) and after ip $^{235}UO_2F_2$ 15 mg/kg for consecutive 3 days (2)

2.1.2 Penetration of $^{235}UO_2F_2$ through intact and abrasive skins

Experiments were carried out on 20 male Wistar strain rats, weighing 165± 15 g. They were divided into 4 groups of 5 rats each, 2 experimental groups and 2 intact skin groups. The rat's hairs on the skin of the back were cut down at area of 9 cm^2, and then smeared carefully with 200 μl, containing 12 mg, of $^{235}UO_2F_2$ in intact or abrasive skins. The abrasive skins was made by sand sheet until occurrence of tissue fluids. After 1 and 6 h contamination, the contaminated skins on the rat's back was washed with physiological saline by cotton[4]. Tissue samples of contaminated skins, kidney, femur, liver and blood were obtained from the sacrificed rats. Each sample of

100 mg was immediately weighed and prepared homogeneous clarity solution in a scintillation vial, and the radioactivities were determined by liquid scintillation counting (see Table 1 and 2).

Table 1

Penetration of radioactivity in intact or abrasive skins contaminated with $^{235}UO_2F_2$ and the decontaminated efficiency from the skin

Group	Time of contamination/ h	No. of rats	Penetration radio-activity/ %	Decontaminated efficiency/ %
Intact skin	1	5	1.36±0.53	98.56±10.82
	6	5	1.55±0.34	98.41±13.54
Abrasive skin	1	5	40.95±9.82* * *	59.03±9.49* * *
	6	5	53.66±8.04* * *	46.29±10.13* * *

* * * $P<0.01$

Table 2

Retention of radioactivity in different organs through intact or abrasive skins contaminated with $^{235}UO_2F_2$

Group	Time of contamination / h	No. of rats	Kidney	Liver	Skeleton	Blood
Intact skin	1	5	0.19±0.08	0.18±0.06	0.30±0.09	0.23±0.10
	6	5	0.18±0.03	0.14±0.10	0.30±0.23	0.18±0.03
Abrasive skin	1	5	0.23±0.09* *	0.20±0.05* *	0.35±0.14	0.17±0.13
	6	5	0.59±0.16* * *	0.18±0.11	0.37±0.19* *	0.12±0.06

* * * $P<0.01$, * * $P<0.05$

It should be stressed that this is extremely important to keep the skin integument free of minor trauma when dealing with radioactive material. It is clear that when such skin traumas do occur, the organism must be protected from $^{235}UO_2F_2$ contamination.

2.1.3 Elimination of insoluble $^{235}U_3O_8$ from gastrointestinal tract by whole body counting

Sexually mature male Wistar strain rats, weighing 120± 10 g were used in this study. Insoluble enriched uranium $^{235}U_3O_8$ with 20.63 % ^{235}U was prepared in 10 % of $^{235}U_3O_8$ suspensive form with 5 % gelatin solution. 100 mg of $^{235}U_3O_8$ were given intragastrically to rats. Then study on elimination of $^{235}U_3O_8$ from gastrointestinal tract by whole body counting[5]. The retentive peculiarity of $^{235}U_3O_8$ in gastrointestinal tract was described by the equation:

$$R(t) = 107.55 \exp(-0.693/0.34) + 1.38 \exp(-0.693/4.05)$$
$$= 107.55 \exp(-2.04t) + 1.38 \exp(-0.17t)$$

where $R(t)$ is elimination rate in percentage, t is time after i.g. in day. Values of

retention were estimated for fast component $T_1 = 0.34$ d and for relatively slow component $T_2 = 4.05$ d.

Experimental rats also were put in to the metabolic cages[6]. The radioactivity of urine and feces was measured through 24 h. Results indicated that the elimination of $^{235}U_3O_8$ was dominantly from feces. The dynamic elimination curve of $^{235}U_3O_8$ in rats was determined by whole body counting. The elimination of ^{235}U from feces was well described by a double-exponential-term expression:

$$E(t) = 541.37 \exp(-0.693/1.33) + 1.54 \exp(-0.693/2.97)$$
$$= 541.37 \exp(-2.1t) + 1.54 \exp(-0.233t)$$

where $E(t)$ is elimination rate in percentage, t is time after i.g. in day.

Values of excretion were estimated for fast component $T_1 = 1.33$ d and for relatively long time component $T_2 = 2.97$ d.

2.2 The retention of $^{235}UO_2F_2$ in different organs of mice

Sexually mature male BALB/c mice, about 11 weeks old and weighing 24 ± 1 g were randomly divided into 9 experimental groups. 4 groups for the whole body retention in different organs, 5 for the testicular retention and clearance of $^{235}UO_2F_2$. There were 5 mice in each group.

Enriched uranium UO_2F_2 with 18.9 % uranium-235 isotope component, its original concentration was 60 mg/ml. Intravenous injection of 20 mg/kg UO_2F_2 was adopted in the experiment. Animals were killed at different times after injection. Kidney, liver and femur of 50 mg were sampled respectively. Samples were put into scintillation vials each. 0.1 ml perchloric acid and 0.2 ml 30 % hydrogen peroxide were added into each vial exactly on the tissue. The vials were placed in water bath at 80 °C for digestion and discoloration for an hour after they were covered properly. Then 6 ml ethylene glycol ether and 8 ml 0.6 % PPO-toluene solution were added into each vial. The vials were shaken and placed in Beckman LS-6800 scintillation counter for measurement of enriched uranium activity.

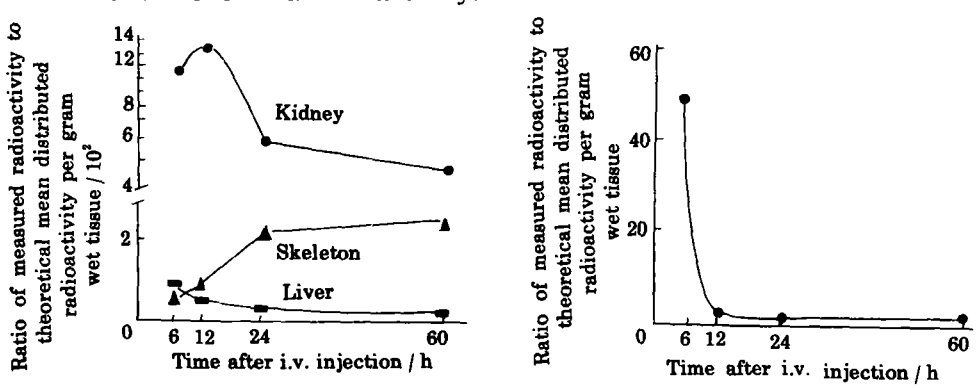

Fig.3, 4 Retention of i.v. injected $^{235}UO_2F_2$ in kidneys—●, Liver—■, skeleton—▲ (3) and testes (4)

At 6, 12, 24, and 60 h after i.v. injection of 20 mg/kg $235UO_2F_2$, samples of mouse kidneys, liver, and femur were taken for measurement. Results showed that the content of enriched uranium in kidneys was the highest of all measured tissues. It reached the peak at 12 h after enriched uranium injection and then gradually reduced, The content in liver also reduced with the increasing time and that in femur increased during the experimental period(Fig.3). The content in testes was measured 10 mg/kg at 6 h after i.v. injection of enriched uranium as shown in Fig.4. It showed a low enriched uranium deposition in testes.

3 DISCUSSION AND CONCLUSION

Enriched uranium UO_2F_2 is the most toxic of uranyl compounds in acute lethality study[7]. $^{235}UO_2F_2$ can decompose into uranyl and fluorion after it gets into the blood stream. These ions combine with components in blood into uranyl compounds and fluorides. These materials may be carried throughout the body by the blood flow although enriched uranium is quantitatively deposited chiefly in the kidneys and bones. It is known that the degree of acute uranium poisoning depends on the amount initially absorbed and the resulting level in the blood stream, irrespective of the route of administration for a given species of strain of experimental animals[8].

From the results of the present study, conclusions are gotten as follows: $^{235}UO_2F_2$ was chiefly localized in kidneys, then in skeleton and liver. While in other organs and tissues the radioactivity was quite low. The radioactivity in skeleton rose steadily while the concentration in kidney and liver droped. Penetration of $^{235}UO_2F_2$ through intact and abrasive skins after contamination with 1 to 6 h contact period, only 1.4—1.6 % of $^{235}UO_2F_2$ was found in the intact skin. This testifies to the important barrier function of the skin integument. However, penetration of $^{235}UO_2F_2$ was dominantly increased in abraded skin. Over 1 h period 41 % of $^{235}UO_2F_2$ applied penetrates through abrasive skin. This value is about 28 times as much as that for intact skin. The dynamic retention of $^{235}UO_2F_2$ through intact or abrasive skins was also dominantly localized in kidneys and skeletons.

Accumulation of insoluble $^{235}U_3O_8$ in gastrointestinal tract was well described by a double- exponential- term expression. Values of retention are estimated for fast component $T_1 = 0.34$ d, and for relatively long term component $T_2 = 4.05$ d.

The retention and distribution of enriched uranium UO_2F_2 in kidneys, liver and femur of mice were similar to those in rats. The selective deposition of enriched uranium in organism was like natural uranium and other diffusible uranium compounds[9,10].

Enriched uranium UO_2F_2 released uranyl ions when it entered blood. Uranyl ions mainly deposited in kidneys, initially in epithelial cells of near uriniferous tubules.

The early deposition depended on the alkaline reserves in the body. The less the alkaline reserves was, the more uranyl ions deposited in near uriniferous tubules of animals.

The liver data showed a steady decline with time and its concentration of enriched uranium was much less than that in kidneys. Femur data show an obvious accumulation with the experimental time. Uranium largely deposited in the inorganic structure of bone. The exchanged enriched uranium might stay in bone tissues for a long time.

The testicular experimental data showed a low enriched uranium level in testes after i.v. injection. This suggests that there was a screen between blood and testes.

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