The Distribution of Zirconium-Niobium-95 in the Mouse Tissues[1)]

By

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(With 1 Text-figure)

During recent years there has been a growing interest in the metabolic behaviors of fission products, i. e. radioactive elements produced by fission of U-235 or Pu-239. Since 1945, the metabolism of fission products in mammals have been actively studied in many institutes belonging to Atomic Energy Commission of U.S.A. and now we are acqainted with the fact that a large majority of fission products in accumulated is skeletal tissues and thus results in serious injuries by radiation. Zr and Nb are also known as the rare elements mainly accumulated in skeletons, but details on their behaviors in soft tissues are not yet studied, so that the present work will contribute to supply this deficit.

Materials and methods

The experimental animals are albino mice of the same age and of the same strain, in the later experiments those of the pure strain NA–2. After administration of the radioactive element, the animal is separately reared in a glass-vessel of 24 cm diameter and 12 cm height.

Zr–95 is originally marked as 'Zirconium in 0.3 normal-hydrochloric acid/ 2% oxalic acid.' This is neutralized with 1N and 0.1N NaOH and diluted to make a Ringer's solution for mouse.

Zr–95 is transformed by β-and γ-emission into Nb–95, which further changes to the stable isotope Mo–95 likewise through β- and γ-emission. Radioactive decays of Zr–95, and Nb–95 calculated from the well-known formulae:

$$N_A = N_0 e^{-\lambda_A t} \quad \text{and} \quad N_B = N_0 \frac{\lambda_A}{\lambda_B - \lambda_A} (e^{-\lambda_A t} - e^{-\lambda_B t}),$$

are shown in Fig. 1. Activity of the daughter nucleus Nb–95 attains its maximum at the 68th day and total activity of both the elements shows a half-life of 118 days. As half-lives of Zr–95 (65 days) and Nb–95 (35 days) are of the same order,

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it is not possible to distinguish them by means of radioactivity. Accordingly, we can not trace each element separately, nevertheless it may be of practical importance to investigate the behavior of Zr-Nb-95 as a fission product.

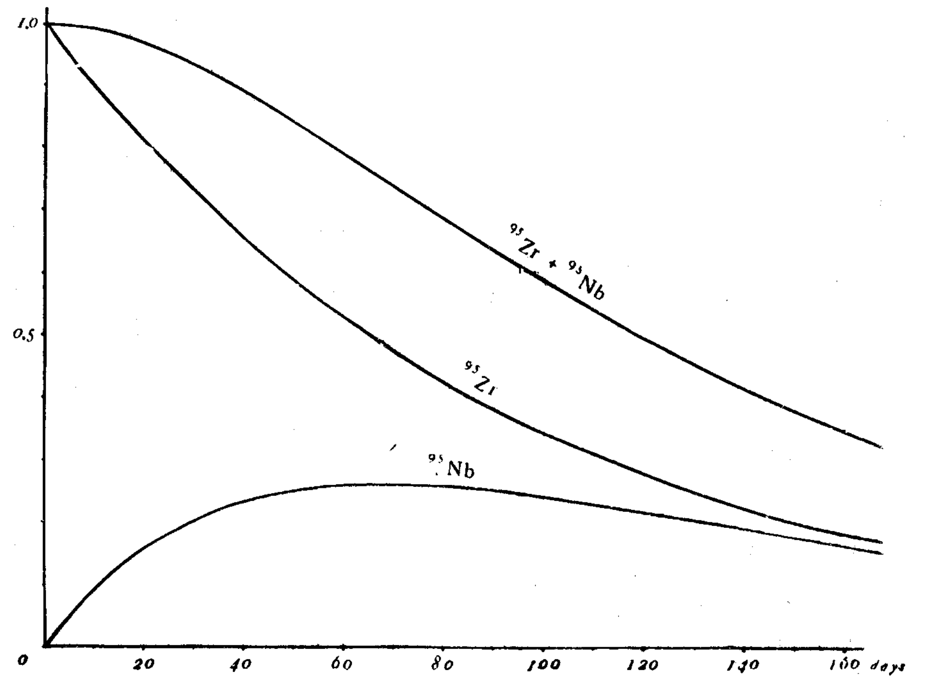

Fig. 1. Radioactive chain of $^{95}Zr \rightarrow {}^{59}Nb \rightarrow {}^{59}Mo$.

The mouse is intraperitoneally injected with Zr–95 at the rate of 1.68 μc (0.02 ml) per gramme body weight. As the average of body weight amounts to 27 g, about 40 μc (0.5 ml) per individual is to be used.

Every one week after injection, the mouse is dissected and the following tissues are treated with, namely: liver, spleen, pancreas, kidney, stomach, small intestine, heart, lung, muscle (M. gastrocnemius), femur, vertebrae and gonads. Every tissue is thoroughly washed with Ringer's solution, put into a Kjeldahl flask and, after weighing, it is brought to wet ashing with $HClO_4$ and HNO_3. After ashing has been finished, water is added to each flask to make up a volume of 5 ml, 0.5 ml of which is put onto an albumin-coated watch-glass (20 mm in diameter) and dried up under an infra-red lamp. Radioactivity of the samples thus obtained is measured by use of a G-M tube with mica window (2.0 mg/cm^2 thick) and a Decatron-type scaler (Aloka DC–1).

Results and consideration

Table 1 shows the process of distribution of Zr-Nb-95 in the tissues obtained from four male mice. Though individual variations can not be excluded by consideration of the experimental data, the distribution of Zr-Nb proves as a whole to follow the certain rules.

Table 1. Radioactivity of mouse tissues (CPM/mg fresh weight) referred to the day of injection

Weeks after injection	1	2	3	4
Liver	28.93	30.12	12.99	7.49
Spleen	32.13	32.78	29.80	11.30
Pancreas	25.25	29.21	13.96	5.58
Kidney	6.30	9.28	5.70	2.51
Stomach	2.66	6.46	3.29	1.45
Intestine	1.45	3.90	0.99	0.67
Heart	6.13	11.84	3.73	2.12
Lung	1.73	4.36	3.46	3.25
Muscle	1.38	2.44	1.95	1.17
Femur	20.54	27.17	32.14	40.73
Vertebrae	15.05	28.99	31.96	51.62
Testis	7.62	18.51	8.36	5.79

A noteworthy point is that Zr-Nb is also accumulated in the skeletal tissues, as evidently shown from the result that radioactivity of femur and vertebrae is still on the way to increase 4 weeks after injection. On the contrary, radioactivity of all kinds of soft tissues coincidently reaches its maximum after 2 weeks and thereafter tends to decrease. Among the soft tissues, liver, spleen and pancreas show higher activity than femur or vertebrae about 1–2 weeks after injection and then their activities rapidly decrease. This fact may indicate that liver etc. are subjected to radiation injuries in the early stage of contamination by the fission product. The other tissues seem to be out of the question, but one must remark that testis shows throughout the highest radioactivity among them.

Excretion of Zr-Nb-95 is so rapid that, after several days, the animal retains only 1/100–1/10 % of the administered dose. Accordingly, one must conclude that Zr-Nb which is accumulated in the skeletal tissues has been transferred from the soft tissues, especially from those with higher activity as liver, spleen and pancreas. It is supposed that removal of Zr-Nb from skeletons may be carried out slowly as well as in the case of Y or Ce and that a chelating agent as for example EDTA may be equally effective for decontamination.

The experiment was also performed with five female mice, but four of them were dead a few days after injection (about 40 μc per individual). Further, three females of NA–2 were injected with Zr–Nb–95 (about 30 μc per individual); they were all dead also in a few days. Even when 1/2, 1/4 and 1/8 of the above dose was injected into two females respectively, each one of those administered with 1/2 and 1/4 dose was soon dead, while those administered with 1/8 dose both survived. These facts seem to indicate a lower tolerance level of the female against Zr-Nb-95, but which comes into question, radioactivity or chemical toxicity? We suppose that the latter may be more responsible, because we can find considerable heperaemia in liver of the dead animals.

Summary

The process of distribution of Zr-Nb-95 in the tissues of male mouse was studied. After intraperitoneal administration, Zr-Nb is more and more accumulated in the skeletons, while the soft tissues attain their maximum contents about 2 weeks after injection. After 1–2 weeks, liver, spleen and pancreas show higher radicactivity than the skeletons.

Literature

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