FACTORS WHICH ALTER THE PARAMETERS FOR EVALUATING INTERNAL EXPOSURE

JUNKO MATSUBARA AND KAZUHO MAEDA

The University of Tokyo, School of Medicine

As a fundamental of dose evaluation of internal exposure, it is necessary to check the factors which alter the dynamics of metal turnover. In the process of mathematical adjustment of the data obtained from retention survey after single exposure of various radionuclides to mice, it was noted that some data showed systematic deviations, from others according to a certain biological or chemical factors. The present report was summarized discussing our experimental results to check the said factors.

1. Methods

Mice were given single injections of radionuclide such as cadmium-109 or zinc-65. The animals were sacrificed at serial time intervals and dissected into more than ten organs. Each organ was radioassayed with scintillation counter. Thus obtained data of organ retentions of a nuclide were processed to fit varieties of mathematical models as described in other reports.[1),2)] Besides, organ concentrations of stable Cd and Zn were followed by atomic absorption spectroscopy of the ashed samples obtained from varied age of mice.

2. Results and Discussion

2.1 Sex

Our data of the whole-body retention of Cd-109 in males and females showed clear sexual difference between them. With exponential model such as $Y = \sum_i Ai \exp(-Bi\ t)$ females gave smaller rate constant Bi than males e.g. in males $B_3 = 0.0032\ (day^{-1})$, in females $B_3 = 0.0020$. While applying to our new retention model[2)] $y = qo\ (1+at)^{-\frac{\lambda}{a}}$, sexual variation was demonstrated more explicitly with a, which we defined as deposition coefficient but not with λ, i.e. rate constant as shown in FIg. 1.

It was also tried to process the data from other workers e.g. the whole-body retention of Am-241 in male and female rats byDurakovic et al.[3)], though it was failed to show the said sexual difference of a, due to the difficulty of obtaining the converged values from the scattered data.

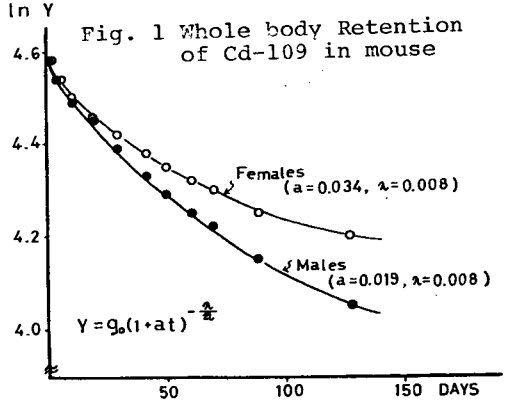


Fig. 1 Whole body Retention of Cd-109 in mouse

2.2 Age

FIG. 2A and 2B shows the long range drifts of concentration of stable cadmium and zinc in various organs of the mouse. Comparing the concentration levels of both elements, they showed somewhat similar relative distributions. while in a long range their dynamics seemed to be quite different. Previously it was also confirmed with repeated retention surveys that the turnover speeds of both radionuclides were quite different as seen in FIG. 3A and 3B.
Correlation coefficients between Cd and Zn data obtained with similar experimental conditions were calculated and listed on TABLE 1.
This shows metabolic speeds of both elements in organisms are strikingly different each other in spite of their similarity of chemical nature.

Fig. 2 Long Range Drifts of Organ Concentrations of Stable Zn(A) and Cd(B)

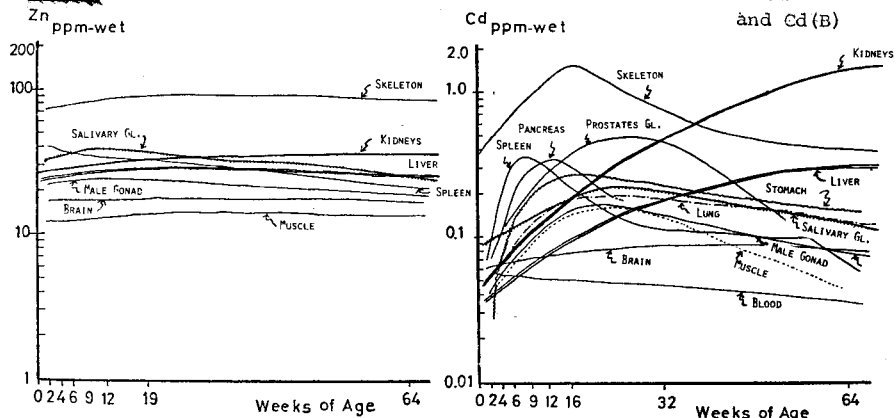
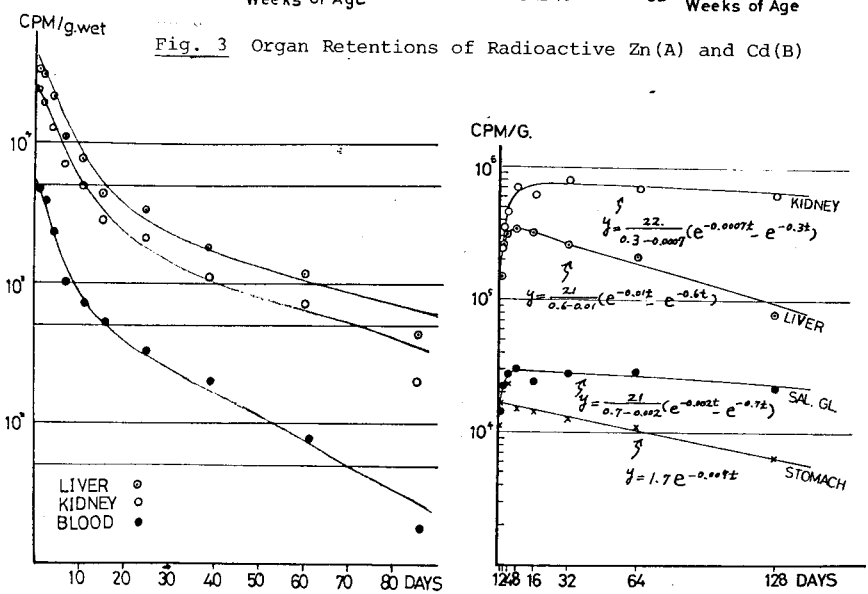


Fig. 3 Organ Retentions of Radioactive Zn(A) and Cd(B)



Usually compartment model is applied for the steady state kinetics. In case of cadmium, the concentration increases even at adult ages as can be noticed on Fig. 2B. Taking into accounts of these facts, it must be established peculiar model for growing animals, i.e. model for non-steady state where metal concentration is shifting according to age.

Vanderploeg et al. gave a note on the explanation of compartment models applied to the system not in a steady state and deduced that the rate constant derived from loss experiment of radionuclide concentration (cpm/g) is ($\beta + \dot{W}/W$) where β is the rate constant obtained from the retention of total amounts of radionuclide in a organ, W is the weight of organ under the observation and $\dot{W}$ stands for dW / dt. The present authors confirmed the above by performing Cd-109 retention survey of growing mouse from 4 weeks until 33 weeks of age. (See Table 2)

3. Levels of the Coexisting Stable Isotope

Single injections of Cd-109 were performed with and without the additions of stable cadmium 0.75 μg/g mouse. Retention of radioactive Cd in kidneys was higher by two fold in no carrier added group, while completely vise versa in the liver (See Fig. 4). This type of opposite reaction of radioactive Cd in the liver to kidneys was confirmed repeatedly. Fig. 5 shows our schema of cadmium distribution and turnover in mouse of both experimental groups, where 70 - 80 % of whole body dose distributes in the liver and kidneys. In the liver the concentration (cpm/g) of Cd-109 is higher in carrier added group. It was speculated that liver can concentrate metal as much as possible where a certain carrier protein must be induced by the addition of metals, though the all amounts can not be transferred to kidneys due to lack of enough carrier. There must exist completely different isotope mixing mechanism between the liver and kidneys. Further experimental studies are necessary to clarify these speculation.

Table 1

1. Correlation of concentrations of Cd and Zn in various organs in the same samples analysed by atomic absorption spectroscopy
   Correlation coefficient, r = 0.348 (n=21, 64 W old)
   r = 0.887 (n=11, 7 W old)
2. Correlation between the concentrations of nuclide obtained from tracer experiment and chemical analysis of atomic absorption spectroscopy
   Cd : r = - 0.10 (n=11, less than 16W old)
   r = 0.76 0.83 (n=11, more than 19W old)
   Zn : r = 0.84 0.92 (n=11, 6 - 24 W old)
3. Correlation of rate constants of Cd and Zn in various organs (Comparison of turnover character)
   r = - 0.037 (n=11, 8 - 25 W old)

Table 2 : Comparison of rate constants observed RI concentrations(cpm/g) with those from RI amounts (cpm) plus W/W.
(Experiments with growing mice)

post-adm. days	weightof organ	W/W	β' from cpm/g data	β from cpm data a plus W/W
2	1.50	0.029	0.038	0.041
4	1.58	0.022	0.033	0.034
8	1.91	0.010	0.030	0.022
25	2.09	0.006	0.026	0.018
35	2.19	0.003	0.021	0.015
50	2.27	0.0015	0.014	0.014
64	2.30	0.0009	0.010	0.013
99	2.33	0.0000	0.010	0.012
123	2.33	0.0000	0.010	0.012
171	2.25	-0.0013	0.010	0.011
202	2.16	-0.0019	0.010	0.010

Fig. 4 A Retention of Cd-109 in liver and kidneys with and without addition of stable cadmium to adult mice.

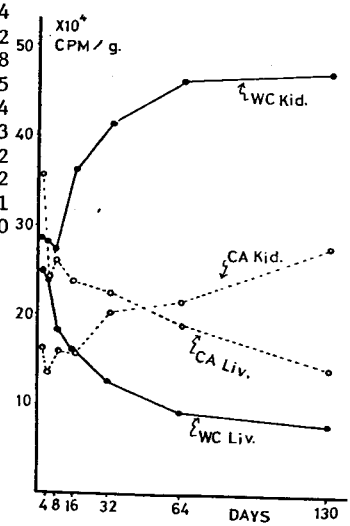


Fig. 4 B The same but in growing mice.

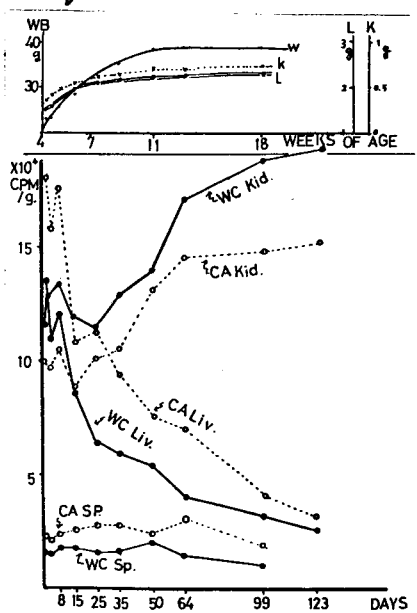
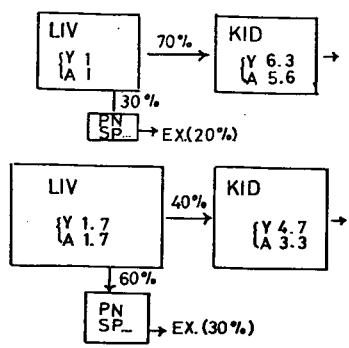


Fig. 5 Schema on the turnover of Cd-109 in the liver and kidneys in no carrier added (upper) and carrier added animals (below).



REFERENCES

1) Matsubara-Khan,J. : Environmental Research, 7,pp54 - 67(1974)
2) Katoh,K. and J. Matsubara, presented in this issue, IRPA 1977
3) Durakovic,A.B., J.G. Hollins and M.G.Starr: Health Physics,24,pp541-546 (1973)
4) vanderploeg,H.A. and R.S. Booth : Health Physics,31,pp57-59 (1976)