EQUATION FOR THE URINARY EXCRETION OF AMERICIUM FOLLOWING A SINGLE UPTAKE

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INTRODUCTION

The equation for the urinary excretion of a radionuclide following a single uptake into the body fluid is useful not only for assessing intake of the radionuclide after its accidental entry, but also for determining the Derived Investigation Level (DIL) of the radionuclide in the routine individual monitoring. For americium there is not an established equation such as the one for plutonium given by Langham. In the present study, the equation for the urinary excretion of americium following a single uptake was derived from the various reported data on urinary excretion of intravenously injected americium (citrate) in various animals. Validity of the equation derived was tested by means of the data on urinary excretion of Am-241 observed in a male following its accidental inhalation in JAERI. The observed urinary excretion of Am-241 in the male agreed fairly well with the calculated ones obtained under the assumption that the Am-241 deposited in the lungs was retained there as a class W material (1) and the Am-241 absorbed from the lungs was excreted in the urine following the derived equation. The urinary excretion of Am-241 calculated under the assumption that the Am-241 absorbed from the lungs was excreted in the urine following the equation derived from the metabolic model given in ICRP Publ. 30 (1) (Fu=0.3) deviated markedly from the observed ones.

DERIVATION OF THE EQUATION FOR THE URINARY EXCRETION OF AMERICIUM FOLLOWING A SINGLE UPTAKE FROM THE ANIMAL DATA

The experimental data on the urinary excretion of americium following its intravenous injection as citrate to various mammals were gathered from the various reference sources (2,3,4,5,6), and shown in Fig.1. Difference between the data of monkey and those of beagle is fairly large. However, it is surprising that the data of a small rodent, rat, are intermediate between those of monkey and beagle. To derive the desired equation, all of the data gathered were used. The derived equation was given as follows (see also the curve in Fig.1) :

$$Yu(t)=0.10\exp(-2.0t)+0.0030\exp(-0.26t)+0.0013\exp(-0.025t)$$

where t is days after injection, and Yu(t) is the fractional daily urinary excretion of americium t days after an intravenous injection of unit amount of americium citrate to the animals.

It was tested in the following sections whether the equation derived above was valid or not as an equation for expressing the human urinary excretion of americium following a single uptake.

DATA ON THE URINARY EXCRETION OF Am-241 IN MAN OBSERVED IN ITS ACCIDENTAL INHALATION IN JAERI

In 1977, a healthy male (34 yr old, 66 kg) inhaled mists of the mixture solution of Pm-147 and Am-241 chloride, when opening the bottle containing the old solution of about 40 mCi Pm-147 chloride and about 1 mCi Am-241 chloride. Vomiting of the mists from the bottle was considered to have occurred by pressure of the degradation gas produced in the bottle. Measurement of the amount of Am-241 in the lungs with a chest counter having a NaI (Tl) detector of 24 cm diameter by 1.3 cm thick and determination of the amount of Am-241 in the urine and feces by chemical analysis were made for about half a year following the inhalation. The results of chest counting showed that the fraction of deposited Am-241 remaining long in the lungs (= long-remaining initial lung burden) was 0.57 nCi, and the results of chemical analysis showed that the initial fecal excretion of Am-241 in the first 5 days after inhalation was 2.0 nCi. The removal half-time of the long-remaining initial lung burden from the lungs was longer than that of a class W material in the dosimetric model of ICRP (1). However,this seems to have been caused by the inclusion of the counts in other organs such as liver and skeleton. In the present study, as described below, the Am-241 in the lungs, the chemical form of which was chloride, was assumed to have behaved there as a class W material. The data on the urinary excretion of Am-241 observed in the accident are shown, as open circles, in Fig.2. The method of chemical analysis used for determination of the amount of Am-241 in excreta appeared elsewhere (7).

TEST OF THE VALIDITY OF THE DERIVED EQUATION FOR MAN BY THE HUMAN DATA OBSERVED IN JAERI

If it is assumed that the Am-241 inhaled in the accident described in the third section was deposited in and cleared from the lungs following the dosimetric model for the respiratory system by ICRP (1), in which all of the americium compounds are assigned to inhalation class W, the intake of Am-241 can be assessed from either the initial fecal excretion or the long-remaining initial lung burden. However, this is only when the AMAD of the aerosol is known. In the present accident, measurement of the AMAD of the mist was not made. Therefore, the intake of the Am-241 was estimated by the use of both the initial fecal excretion and the long-remaining initial lung burden, using the prerequisite that the estimates from both the values are the same. This procedure gave the intake of 4.3 nCi of the Am-241 aerosol having the AMAD of 1.3 μm. These values were used in the following test as the intake and AMAD of the aerosol inhaled.

In order to test validity of the equation derived in the second section for man, the urinary excretion of the Am-241 inhaled was calculated assuming that the Am-241 transferred to the body fluid from the lungs was excreted in the urine following that equation. The results are shown in Fig.2 as the curve A. Although the values thus calculated are somewhat smaller than the observed ones, these values agree fairly well with each other. The curve B in Fig.2 shows the values calculated under the assumption that the Am-241 absorbed from the lungs was excreted in the urine following the equation derived from the metabolic model given in ICRP Publ.30 (1), where Fu was assumed as 0.3. It is obvious from the figure that these values deviate markedly from the observed ones. It is thus seen that the equation derived here from the animal data is satisfactorily applicable to the human case, apparently better than that derived from

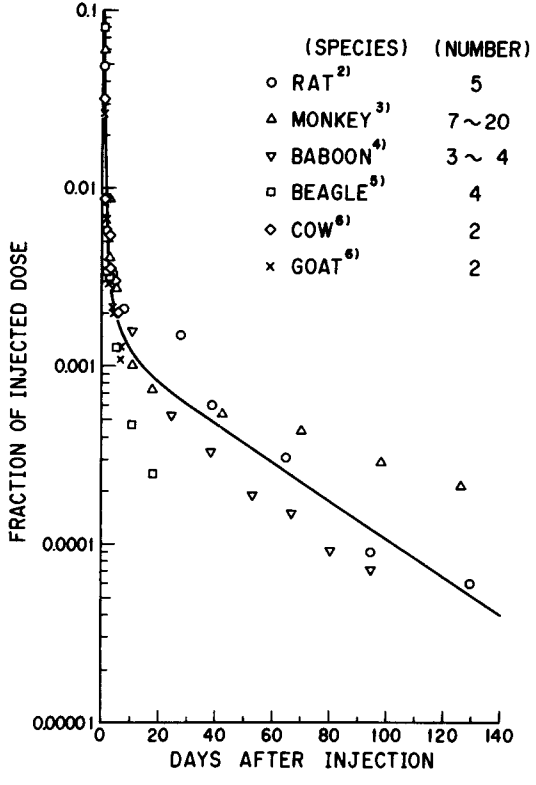

Fig.1. Daily urinary excretion of Am-241 in various animals following an intravenous injection of Am-241 citrate.

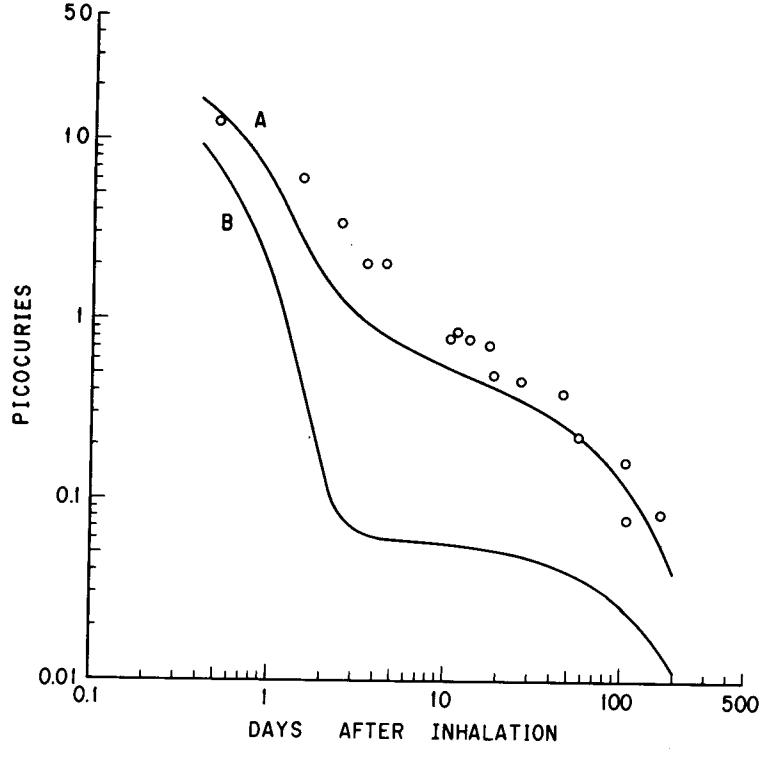

Fig.2. Daily urinary excretion of Am-241 in man following an inhalation of Am-241 chloride. For the curves A and B, see the text.

the metabolic model given in ICRP Publ.30 (1). The somewhat larger observed values than the calculated ones might have occurred owing to the larger absorption of Am-241 than that of the class W material, because the chemical form of the Am-241 inhaled was soluble americium chloride. Zalikin et al. reported (8) the large absorption of Am-241, administered intraperitoneally as chloride, from the rat lungs.

Parkinson et al. derived (9) the equation for the urinary excretion of curium, a chemically analogous element to americium, following a single uptake, from the data on the urinary excretion of curium absorbed from the wound site in man. Validity of the present equation for man might also be supported by the fact that the values calculated from their equation for curium are similar to the present ones in the tested period.

CONCLUSION

The results above show that the equation for the urinary excretion of americium derived here from the animal data can satisfactorily simulate the urinary excretion of americium in man.

However, it must be kept in mind that the present test was carried out under many presumptions. Namely, the amount of intake and the rate of absorption from the lungs of inhaled Am-241 were obtained assuming the model which is inherently given for derivation of the annual limit on intake or the derived air concentration of radionuclides. It is hoped that further test to confirm the validity of the equation derived here for man will be performed.

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