Tritium Metabolism in the Human Body

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Abstract

In the radiation safety assessment prior to the construction of the first commercial spent nuclear fuel reprocessing plant in Rokkasho, Japan, estimation of the internal radiation dose to the public due to tritium was done using the dose conversion factors for the ingestion of HTO and organically bound tritium (OBT), which were derived based on the ICRP metabolic model of hydrogen in the human body. The ICRP metabolic model is very simple and comprised of 2 compartments having biological half-lives of 10 and 40 days, respectively. Although the biological half-life of tritium water (HTO) in humans was examined in several cases such as accidental intakes or experimental administrations, actual data on the metabolism of OBT are quite limited both experimentally and observationally. The objective of this research program is to reexamine experimentally the behavior of tritium in the human body for more realistic dose estimation. In the experiment, the stable isotope of hydrogen, deuterium (D), was used as a substitute for tritium.

The isotopic ratios (D/H) in breath air, blood serum and urine of participants administered D-labeled glucose or D_2O, together with controls, were determined by a mass spectrometer during one week. The temporal changes in (D/H) ratios in breath air of participants who ingested D-glucose were largely different from those in ^{13}C isotopic ratios in breath air after administration of ^{13}C-labeled glucose in a previous study. This implied probable differences in the behavior of carbon and hydrogen even in the same organic material. The observed half-times of the excretion of D in both serum and urine in a short-term observation were 7.7 -9.9 days, which were consistent with the reference values previously reported and also with the ICRP model results. Longer half-lives exceeding 1 month will be studied hereafter. All procedures of the experiment were approved by the IES Review Board for Human Subject Experiments and written informed consents were obtained from all participants.

Table 1 Half-life of D concentration in breath (day)

Administration	Half-life 1st	Half-life 2nd
D_2O	3.5×10^{-3}	5.4
D-labeled Glucose	2.6×10^{1}	–

Table 2 Half-life of D concentration in serum (day)

Administration	Half-life
D_2O	8.0
D-labeled Glucose	9.7

Table 3 Half-life of D concentration in urine (day)

Administration	Half-life
D_2O	7.7
D-labeled Glucose	9.9

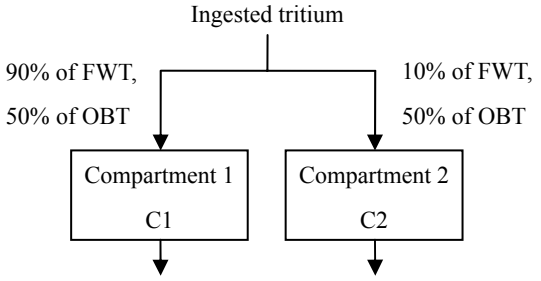

Fig. 1 ICRP tritium metabolic model
C1: FWT compartment ($T_{1/2}$=10 days)
C2: OBT compartment ($T_{1/2}$=40 day).

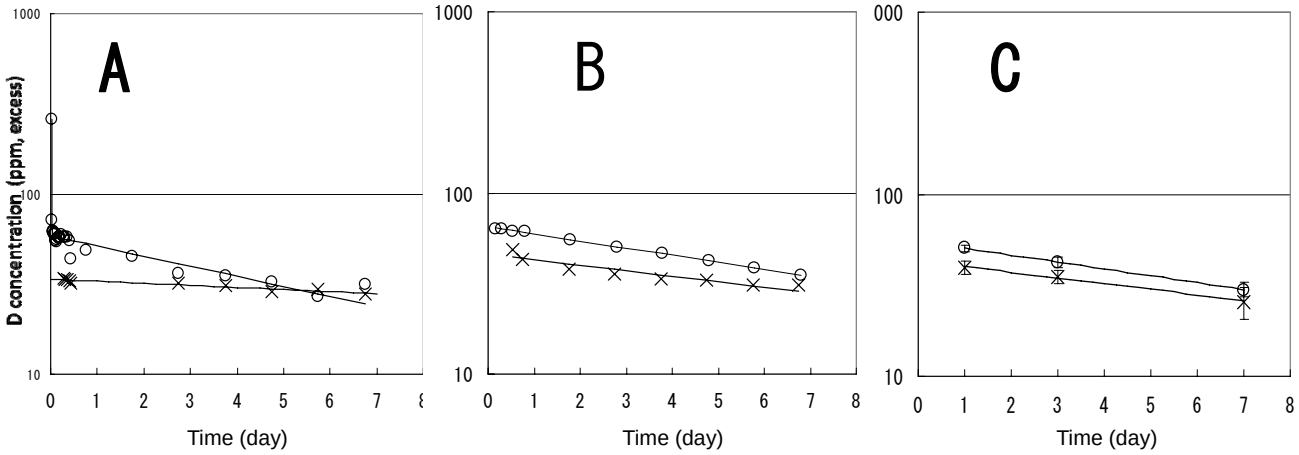

Fig. 2 D concentrations in human breath, urine and serum, after oral administration of D_2O and D-labeled glucose. A: breath, B: serum, C: urine. ○: D_2O, ×: D-labeled glucose.

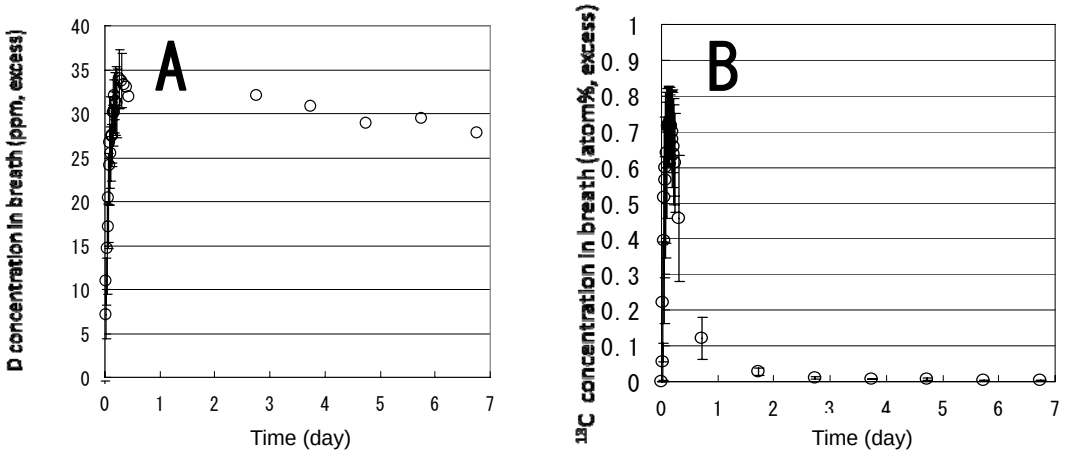

Fig. 3 D and ^{13}C concentrations in human breath, after oral administration of D- and ^{13}C-labeled glucose A: D-labeled glucose, B: ^{13}C-labeled glucose.

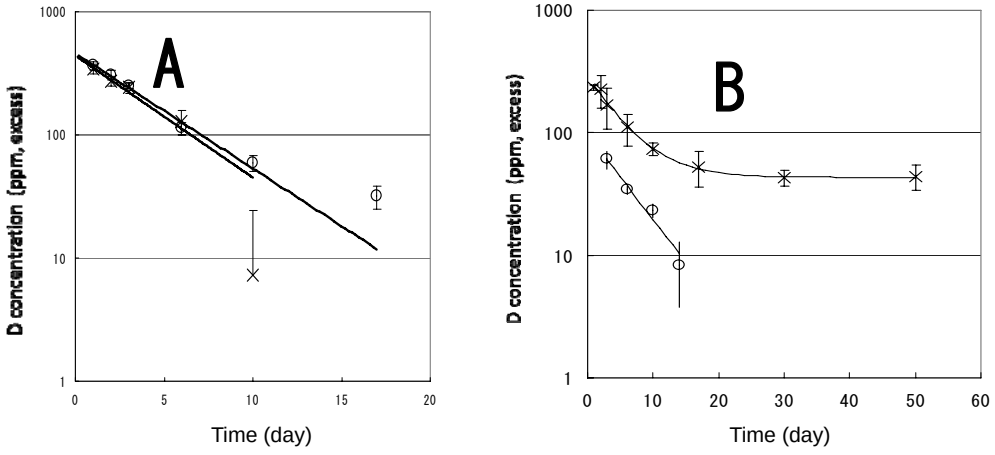

Fig. 4 D concentrations after oral administrations of D_2O and D-labeled glucose in serum and liver of experimental rats. A: serum, B: liver. ○: D_2O, ×: D-labeled glucose.