Development of Calculation Module for Intake Retention Functions based on Occupational Intakes of Radionuclides

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1. Introduction

In internal dosimetry, intake retention and excretion functions are essential to estimate intake activity using bioassay sample such as whole body counter, lung counter, and urine sample. Even though ICRP (International Commission on Radiological Protection) provides the functions in some ICRP publications, it is needed to calculate the functions because the functions from the publications are provided for very limited time. Thus, some computer program are generally used to calculate intake retention and excretion functions and estimate intake activity.

OIR (Occupational Intakes of Radionuclides) [1] will be published soon by ICRP, which totally replaces existing internal dosimetry models and relevant data including intake retention and excretion functions. Thus, the calculation tool for the functions is needed based on OIR.

In this study, we developed calculation module for intake retention and excretion functions based on OIR using C++ programming language with *Intel Math Kernel Library* [2].

2. Material and Method

2.1 Intake Retention Functions

Intake retention functions mean retained activity in organ or tissue at time t after intake of 1 Bq. Similarly, intake excretion functions mean activity in excreted sample such as urine and feces at time t after intake of 1 Bq. Intake retention and excretion functions are generally calculated using compartment model and linear algebra. In the compartment model, each organ and tissue is considered as independent compartment. The transfer between compartments is described by first-order kinetics with transfer coefficient, r (d^{-1}). The activities in each compartment at time t after intake of 1 Bq can be calculated by solving the first-order simultaneous differential equation. In order to solve the equation simply, linear algebra using matrix is commonly used as following equation (1) [3]:

$$q(t) = e^{[A]t} q(0) \quad (1)$$

In this equation, q(t) is the vector including activities in each compartment at any subsequent time t, and q(0) is the initial vector that contains the initial activities in each compartment. The matrix [A] is formed by modifying a transfer rate matrix [R] as following equation:

$$a_{ii} = -\sum_{\substack{j=1 \\ j \neq i}}^{N} r_{ji} \; ; \; a_{ij}=r, \text{ for } i \neq j \quad (2)$$

where r_{ji} is a transfer rate from compartment i to j and compose the matrix [R].

Likewise, calculation of the functions involves matrix operation which takes so long calculation time. In order to solve this problem in development of the calculation module, we used *Intel Math Kernel Library* which include very fast matrix calculation algorithm and is also used in MATLAB.

2.2 OIR

In 2007, ICRP published ICRP publication 103 [4] to replace ICRP publication 60 [5]. Based on ICRP publication 103, ICRP will release OIR in which internal dosimetry models and relevant data will be totally changed. In the OIR, respiratory tract model in ICRP publication 66 [6] is somewhat revised and alimentary tract model in ICRP publication 100 [7] is adopted. In the revised respiratory tract model, deposition fraction is changed and absorption parameters should be used directly instead of absorption type (F, M, S). In addition, systemic biokinetic model for most nuclide is replaced.

When we developed the calculation module, we considered these dramatic changes. Deposition fractions and half-life data from ICRP publication 107 [8] are built-in the module. Transfer rates for revised respiratory tract model and alimentary tract model are also included for database of the module. In order to calculate the functions using the developed module, user has to input some data as shown in Table I.

Using the developed calculation module, we calculated intake retention and excretion functions for particulate inhalation of ^{137}Cs and ^{131}I and compared existing functions from ICRP publication 78 [9]. Fig. 1 and 2 show the systemic biokinetic model for cesium and iodine in OIR, respectively. AMAD (Activity Median Aerodynamic Diameter) was assumed as 5μm and default absorption parameters were used.

Table I: Input Parameters in the Module

Nuclide	Element symbol, Mass number
Intake route	Inhalation (particulate, gas/vapor), Ingestion, Injection
Absorption	f_r, s_r, s_s, f_A
Time	Maximum time, Time interval

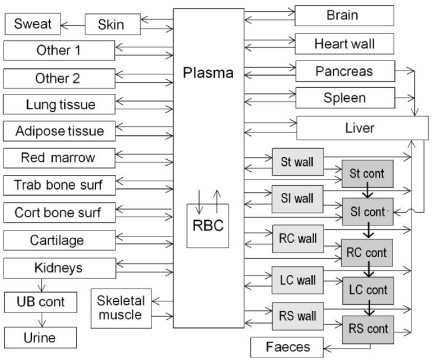

Fig. 1. The systemic model for cesium in OIR.

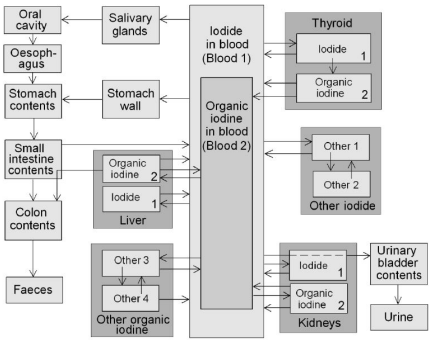

Fig. 2. The systemic model for iodine in OIR.

3. Results

Fig. 3 shows the whole body retention function, daily urinary excretion function, and daily fecal excretion function for inhalation of ^{137}Cs using the developed calculation module. Fig. 4 shows the whole body retention function, daily urinary excretion function for inhalation of ^{131}I using the developed module.

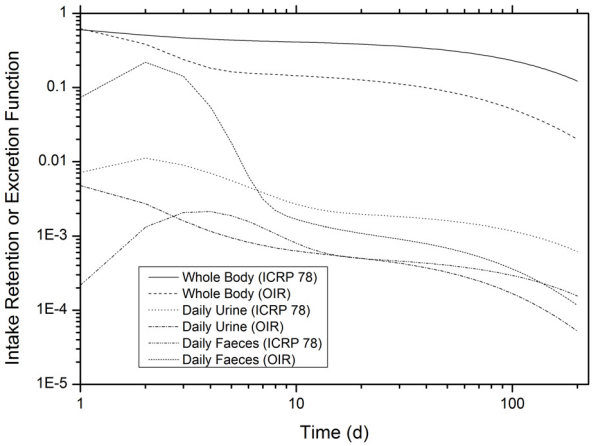

Fig. 3. Comparison of intake retention and excretion functions for inhalation of ^{137}Cs in ICRP 78 and OIR.

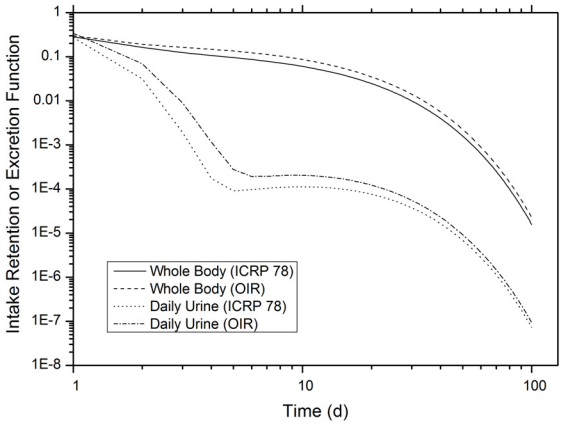

Fig. 4. Comparison of intake retention and excretion functions for inhalation of ^{131}I in ICRP 78 and OIR.

4. Conclusions

In this study, we developed the intake retention and excretion function calculation module based on OIR using C++ programing language. The developed module covers huge changes in OIR and can calculate the functions rapidly using *Intel Math Kernel Library*. We expect that the developed module will be useful after OIR is applied in internal dosimetry.

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