Calculation tool for Iodine 131 biodistribution depending on the aerosol particle distribution

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Introduction

Radiation damage to tissues depends on radiation exposure levels. Therefore, we have studied accurate estimations of radiation exposure levels so far. Recently, we developed a tool that can calculate the respiratory tract deposition of radionuclides on the basis of polydisperse particle size distribution. As a next step, there is a need for a new calculation tool for the biodistribution of radionuclides because some parts of radionuclides deposited in the respiratory tract are absorbed into the body. Development of a calculation tool for ^{131}I biodistribution depending on aerosol size distribution are performed in this study. The validity of the developed tool and the demonstration using polydisperse particle size distribution were also done.

Materials and Methods

Calculation model: Clearance model given in International Commission on Radiological Protection (ICRP) Publication 66 and 71 was used for the biodistribution in each respiratory tract region. Biodistribution models of ^{131}I particle in the body given in ICRP Publication 30, 56 and 67 was used for this study in that the Japanese regulation is based on these models. Euler type solution was used for the calculation of the simultaneous ordinary differential equations for the clearance model in each region.

System of the tool: Microsoft Office Excel 2016 was used for the development of the tool in this study. The users can get output data by inputting initial data, as shown in Figure 1.

Validation: Validation of the tool for this study was performed by comparing it with an existing software that is Monitoring to Dose Calculation Ver. 3 (MONDAL3) .

Demonstration: The polydisperse particle size distribution in previous our study was used as a matter of convenience for demonstration, as shown in Figure 2.

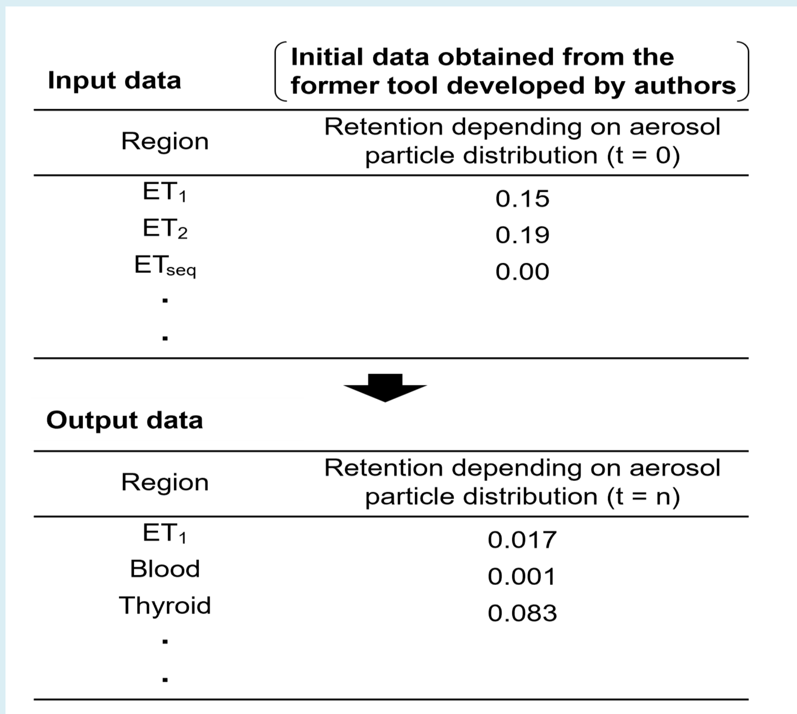

Figure 1. Outline of the developed tool.

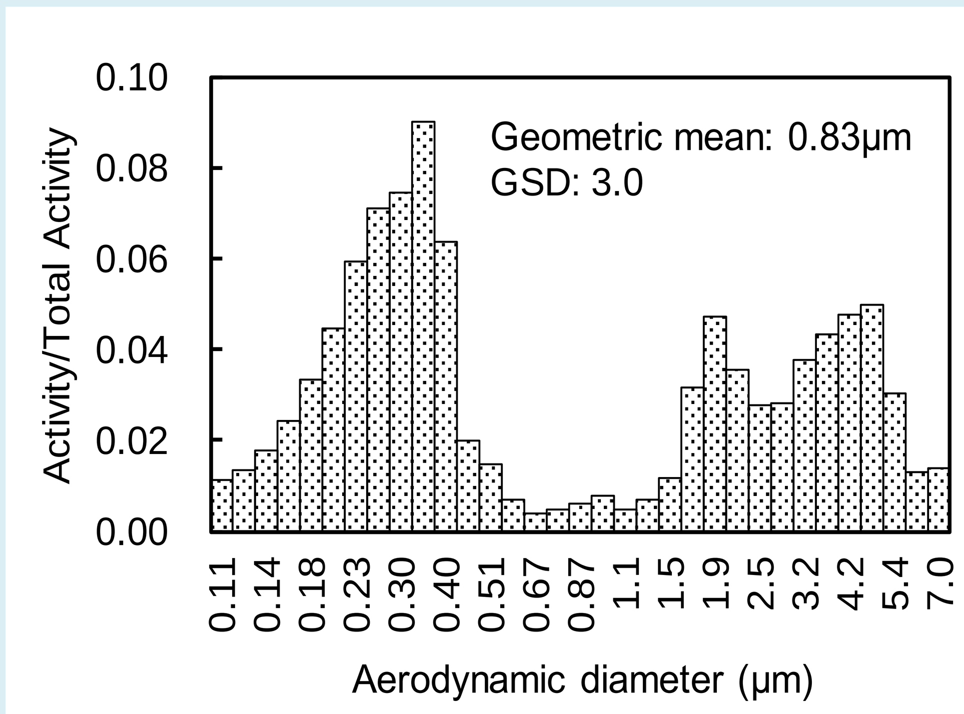

Figure 2. A polydisperse particle size distribution as a matter of convenience in this study.

Results and Discussion

Validation

The thyroid retention, daily urinary excretion and daily faecal excretion obtained from the tool in this study was 99% or more identical to those obtained from MONDAL3.

Demonstration

The results of retention of each region directly obtained from the polydisperse particle size distribution and retentions of each region obtained from ICRP default condition (i.e., log-normal distribution) are shown in Table 1. There were differences between the results of the retentions obtained from the polydisperse particle size distribution and log-normal distribution.

Table1. Results for the demonstration (example).

Region	Ratio of retentions (polydisperse particle size distribution/GM and GSD)			
	0 day[a]	1st day[a]	4th day[a]	16th day[a]
ET1	1.09	1.09	—[b]	—[b]
BB1	1.24	1.13	—[b]	—[b]
AI1	0.94	0.94	—[b]	—[b]
Bood	—[b]	1.04	1.04	1.04
Thyroid	—[b]	1.04	1.04	1.04
Rest of body	—[b]	1.04	1.04	1.04
⋮	a: Elapsed time after inhalation. b: Almost zero divided by almost zero.			

Conclusion

Accurate calculation of ^{131}I biodistribution under actual atmospheric environments during the accidents (e.g., release of radionuclides from nuclear power plants and NORM facilities) would be possible by using the tool in this study and the former tool developed by authors.

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