Study of the Influence of Biokinetic Distribution in Human Body on the Efficiency Response of Lung Counters

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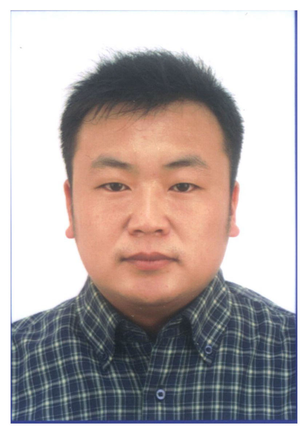

1. Introductions

Physical phantoms, such as the Livermore torso phantom, are commonly used to calibrate the detection efficiency of lung counters, which usually has a static and uniformly activity distribution. However, the real distribution in body varies with time as predicted by biokinetic model. Numerical calibration based on human voxel phantoms and Monte Carlo simulation provides a powerful capability to simulate the bio-kinetic activity distribution in human body. By taking the advantage of the above technique, this paper is to study the influence of biokinetic distribution of Am-241 in body on the detection efficiency of a lung counter configured with four HPGe detectors.

2. Materials and Methods

2.1 CRAM phantom and biokinetic model

Numerical calibration used in this paper has been developed and validated in previous studies[1,2,3]. The CRAM voxel phantom representing Chinese Reference Adult Male was used in this study [4]. In order to couple CRAM to the biokinetic model accordingly, the respiratory tract was sub-segmented into ET1, ET2, BB and lungs in CRAM as in figure 1. DCAL software was used to calculate the biokinetic distribu-tion for Am-241 acute inhalation[5].

The biokinetic detection efficiency is calculated by two steps: the organ-specific detection efficiency is calculated in advance for each organ, and then multiplied by their corresponding activity content to obtain the total detection efficiency.

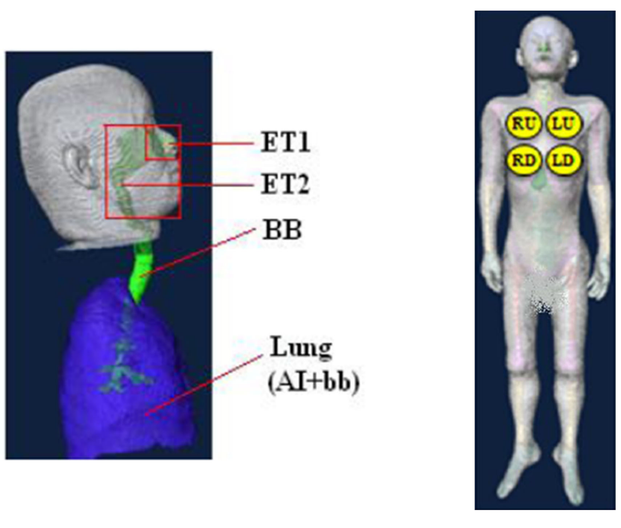

Fig. 1 Respiratory tract

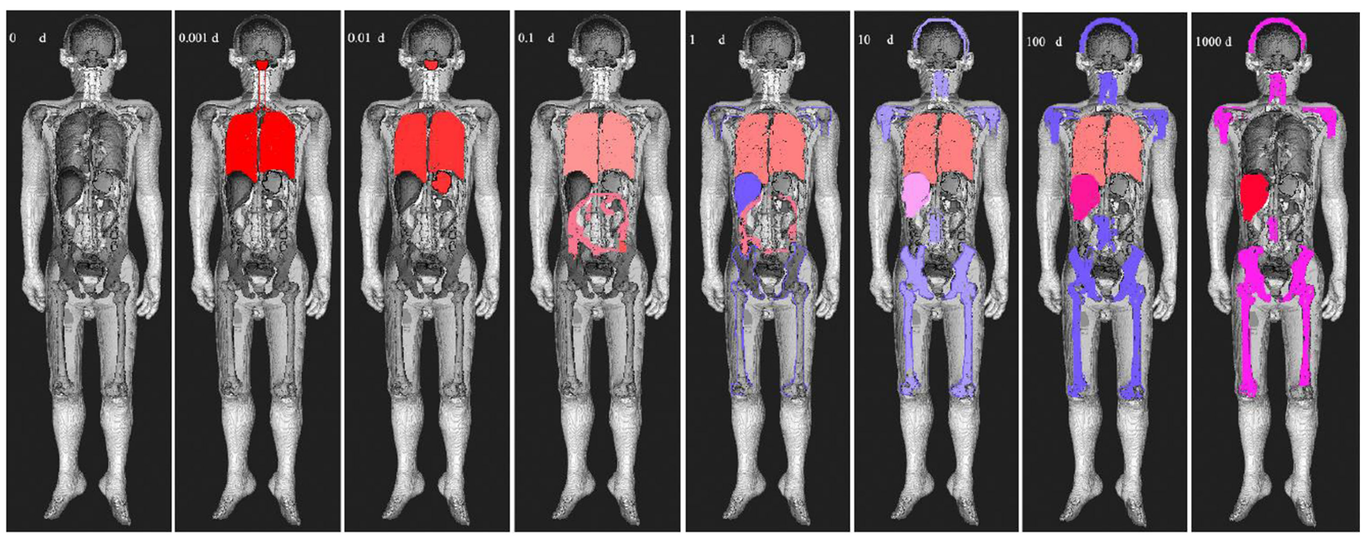

Fig.2 Activity distribution as the function of time in CRAM

2.2 Calculation of the influence of biokinetic activity distribution

The difference between I_hom and I_Bio can be calculated as follows, which indicates the errors of traditional method.

$$\mathbf{err} = \frac{\mathbf{I_{hom}} - \mathbf{I_{Bio}}}{\mathbf{I_{Bio}}} = \frac{\sum \boldsymbol{\eta}_i \cdot \mathbf{m_i(t)}}{\boldsymbol{\eta}_{Lung} \cdot \mathbf{m_{Lung}(t)}} - \mathbf{1}$$

where, I_hom is the intake using the traditional calibration method, I_Bio is the realistic intake after considering biokinetic distribution; mi(t) is the activity in organ i as the function of time t, i is the organ-specific peak detection efficiency for 59.5 keV photons (counts/s/Bq).

3. Results

As shown in figure 3, by using the classical static calibration method, the radionuclide activity for M-absorption type could be overestimated up to 50% (AMAD=1μm), 150% (AMAD=5μm) for Am-241 in the early period (<3d) after acute inhalation; and a relative flat response exists for the period from 3d to 100d, in which the overestimation are 10%-40% for 1μm, and 20%-60% for 5μm respectively; however, the overestimation would become worse with the time extended, e.g., 160% for 1μm at 300d.

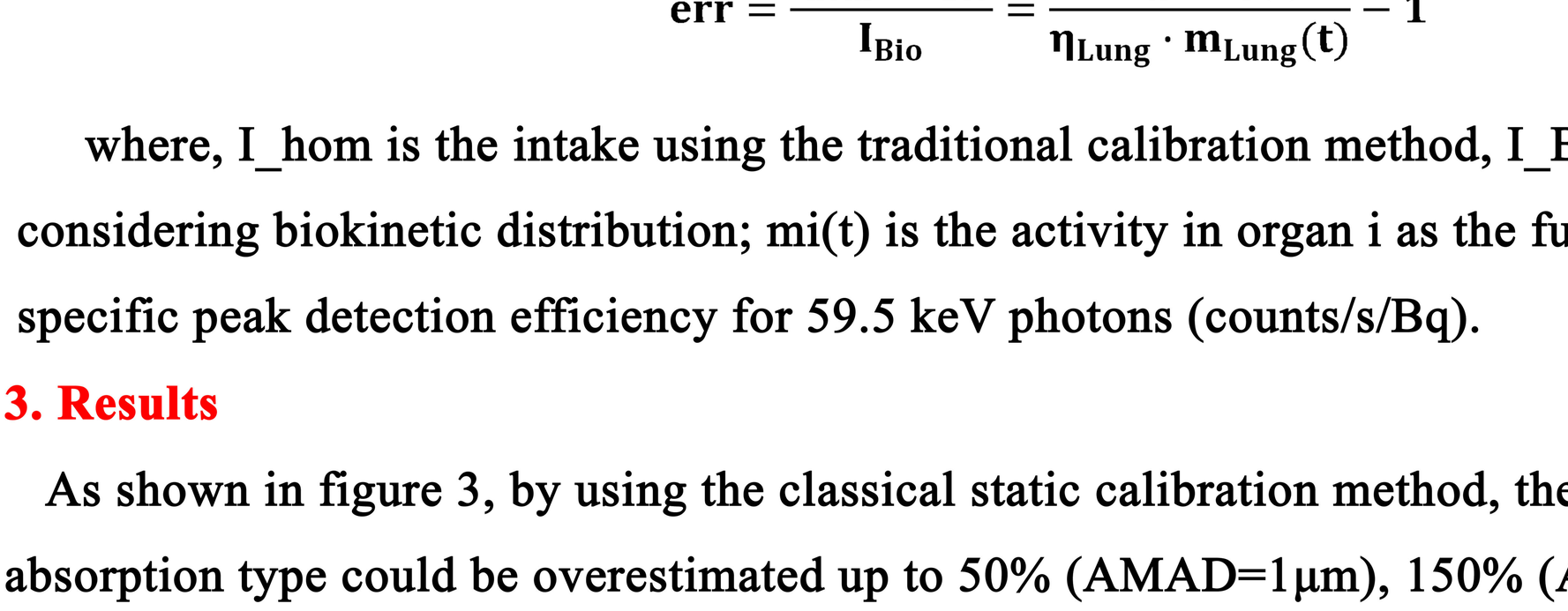

Fig.3 Errors of classical method for Am-241 with M-(left) and S-(right) type

References

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