Development of image reconstruction method for a multiple-isotope PET using ^{44m}Sc†

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Positron emission tomography (PET) is a powerful tool for radio-tracer imaging in a living biological object. However, conventional PET is useful only for single-tracer imaging because of the energy constancy of annihilation photons, which are utilized for PET imaging. In order to improve PET imaging, we have developed a new small-animal PET system that can be used for multiple-tracer simultaneous imaging. Our PET system, named multiple-isotope PET (MI-PET), detects not only annihilation photons but also prompt γ-rays, which are emitted successively after positrons, using additional γ-ray detectors. Previously, we succeeded in proving the basic principle of MI-PET using a prototype system.[1,2)]

Because of the imperfectness of the prompt γ-ray detection in MI-PET imaging with a pure positron emitter and positron-γ emitter, an image for the pure positron emitter taken by MI-PET is superposed by the positron-γ emitter. Therefore, to create an isolated image of the pure positron emitter, we developed an image reconstruction method based on subtraction between data with the absence (data-D) and presence (data-T) of the prompt γ-ray detection. For this subtraction, the spatial normalization of the prompt γ-ray sensitivity is needed. Therefore, long-period normalization scans of a positron-γ emitter, ^{44m}Sc, was performed using a cylindrical phantom 180 mm in length and 78 mm in diameter. These normalization data were also used for the analysis of the counting-rate dependence of the sensitivity based on its proper decay half-life of 58.6 h. The initial activity of the ^{44m}Sc phantom was 2.45 MBq, and the measurement time was 235 h, which corresponds to approximately 4 half-lives.

To evaluate the practical performance of the developed image reconstruction method, dual-isotope mouse imaging was performed using ^{18}F-FDG and a simple substance, ^{44m}Sc. In this experiment, 1.13-MBq of ^{18}F-FDG and 1.23-MBq of ^{44m}Sc were administered to an 8-week-old normal male mouse by a tail vein injection. After 38 min from administration, a 30-min scan with bed motion was performed under anaesthesia. This animal experiment was performed in accordance with the Principles of Laboratory Animal Care (NIH Publication No. 85-23, revised 1985) and approved by the Institutional Animal Care and Use Committee (IACUC) of RIKEN, Kobe Branch.

Scandium-44m was produced at RIBF *via* the ^{45}Sc$(d, p2n)^{44m}$Sc (for normalization scan) and ^{44}Ca$(d, 2n)^{44m}$Sc (for mouse imaging) reactions with a 24-MeV deuterium beam from the AVF cyclotron, purified by chemical processes at the hot lab, and transported to the RIKEN Center for Biosystems Dynamics Research in Kobe.

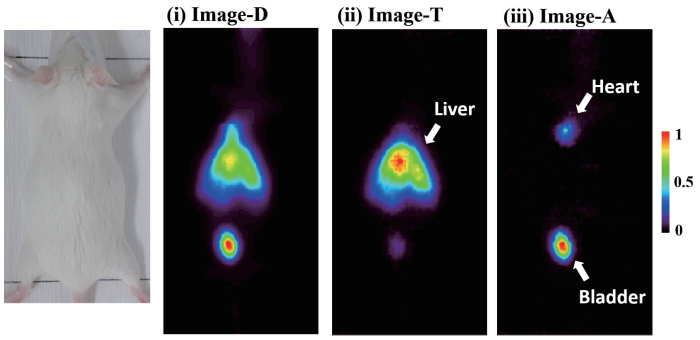

Fig. 1. Photograph (left) and reconstructed images of a mouse administrated with ^{18}F-FDG and ^{44m}Sc. (i) image-D (^{44m}Sc and ^{18}F-FDG), (ii) image-T (^{44m}Sc), and (iii) image-A (^{18}F-FDG).

Table 1. VOI analysis of the mouse. Values are shown in kBq.

	Image-D	Image-T	D-T	Image-A
Heart	31.7	10.2	21.5	23.9
Liver	421.3	427.6	−6.3	0.9
Bladder	69.0	9.2	59.8	77.3

Reconstructed mouse images from data-D (image-D: ^{44m}Sc and ^{18}F-FDG) and data-T (image-T: ^{44m}Sc) as well as an isolated image of the pure-positron emitter (image-A: ^{18}F-FDG) are shown in Fig. 1. From image-T, we can clearly observe ^{44m}Sc accumulation in the liver, whereas from image-A, ^{18}F-FDG accumulated in the heart and urinary bladder. These distributions are reasonable from a physiological viewpoint.

To make a quantitative analysis, 3D volumes of interest (VOIs) were set on the heart, liver, and bladder for image-D, image-T, and image-A. The values of these VOIs and direct subtraction between image-D and image-T (D-T) are listed in Table 1. The D-T activity in the liver was negative. However, activity in the liver of image-A, which has no biological specific accumulation of ^{18}F-FDG, was nearly zero and was comparable with other non-accumulated sections. From this result, we concluded that our newly developed image-A isolation method is useful for practical multiple-isotope imaging using MI-PET.

References
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† Condensed from the article in Jour. of Inst., (in press) (2021)

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