Live mouse imaging with ^{44m}Sc by a multiple-isotope PET

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We have been developing a multiple-isotope positron emission tomography (MI-PET) system that can analyze the dynamics of multiple tracers. Using a positron-γ emitter, which emits de-excitation γ-ray as a tracer after the positron emission in β-decay, the MI-PET system identifies the tracer by detecting the prompt γ-ray emitted after the positron emission. Figure 1 shows a schematic illustration of the developed MI-PET prototype system. This system is composed of a PET scanner and additional γ-ray detectors.[1)] In this system, in addition to conventional PET imaging, coincidence among the additional detectors and the PET scanner can be performed. We expect that MI-PET will be used for drug discovery research by direct comparison between old and new drugs.

For multiple-isotope imaging using MI-PET, at least one positron-γ emitter is necessary as a tracer. Scandium-44 is one of the promising radioactive-tracer candidates for MI-PET because of its large positron and γ-ray emission ratio and moderate half-life (^{44}Sc: 3.97 h, ^{44m}Sc: 58.61 h). In our previous work, we performed dual-isotope phantom imaging using ^{44m}Sc and ^{18}F (pure positron emitter) and evaluated the basic imaging performance of MI-PET for ^{44m}Sc.[2)]

Therefore, before the future development of a ^{44m}Sc-labeled drug for MI-PET applications, in order to test the practical imaging ability of the MI-PET system for ^{44m}Sc, we conducted dual-isotope live mouse imaging using ^{44m}Sc, which is a simple substance.

Scandium-44m was produced at the RIKEN AVF cyclotron via the reaction ^{44}Ca$(d, 2n)^{44m}$Sc with a 24-MeV deuterium beam. As the irradiation target, ^{44}CaO (97.0% enriched ^{44}Ca isotope) powder was pressed into a disk of 10-mm diameter. The irradiated target was dissolved in 6 M HCl and purified by the chemical processes.[2)] Finally, approximately 2 MBq of pure ^{44m}Sc was produced and transported to RIKEN Kobe campus for the imaging experiment. Most of the short-lived by-product, ^{44}Sc, decayed out during transportation.

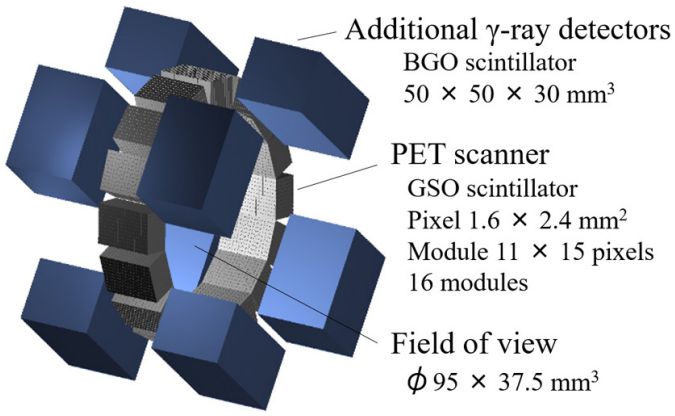

Fig. 1. Schematic illustration of the developed MI-PET prototype system.

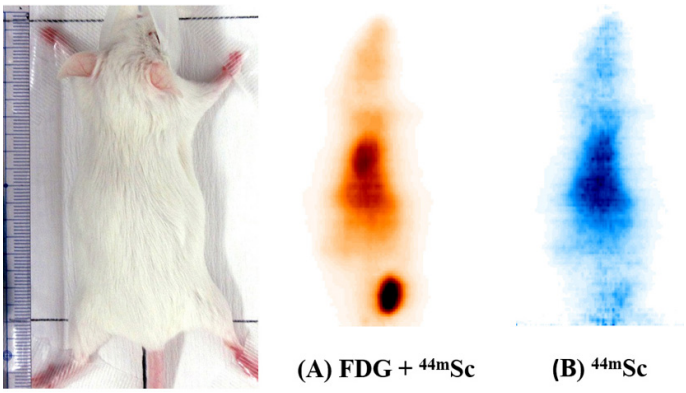

Fig. 2. Images of a live mouse with ^{44m}Sc and ^{18}F-FDG injections (maximum intensity projection images). The reconstructed images were acquired with the absence (A) or presence (B) of γ-ray coincidence.

In the mouse imaging experiment, 197 kBq ^{44m}Sc (simple substance) and 198 kBq ^{18}F-FDG were administered to an 8-week-old normal male mouse by tail-vein injection. Five minutes after administration, a 30-min whole-body scan was performed under anesthesia.

The result of dual-isotope mouse imaging is shown in Fig. 2. From the reconstructed images with the absence (A) or presence (B) of the prompt γ-ray detection, image (A) reflects the distribution of both ^{18}F-FDG and the ^{44m}Sc tracer, whereas image (B) reflects the isolated image of the ^{44m}Sc tracer. In these images, we can clearly observe the difference between ^{18}F-FDG and ^{44m}Sc distributions, *i.e.*, ^{18}F-FDG is distributed in the heart and urinary bladder, whereas ^{44m}Sc distributed in the liver.

From this experiment, we successfully demonstrated the practical feasibility of dual-isotope imaging using MI-PET with ^{44m}Sc as the second tracer. In the future, we will synthesize a useful MI-PET drug labeled by ^{44m}Sc and perform multiple-drug imaging on disease model animals.

References

1) T. Fukuchi *et al.*, Med. Phys. **44**, 2257 (2017).
2) T. Fukuchi *et al.*, RIKEN Accel. Prog. Rep. **52**, 207 (2019).

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