Medical Applications

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Functional imaging by fluorescent X-ray CT

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Introduction

The fluorescent X-ray computed tomography (FXCT) with synchrotron radiation is being developed to depict the distribution of specific elements inside the object without slicing procedure [1-7]. FXCT system with a spatial resolution less than 1 mm and short data acquisition was constructed by using a germanium detector [8]. To assess the functional information of various human disease models of animals, FXCT imaging was performed after injecting various types of non-radioactive iodine labeled agent.

Methods and material

The experiment was carried out at the bending-magnet beam line BLNE-5A of the Tristan accumulation ring (6.5 GeV) in Tsukuba, Japan. The photon flux rate in front of the object was approximately 9.3 x 10^7 photons/mm^2/s for a beam current of 40 mA. FXCT system consists of a silicon (111) double crystal monochromator, an x-ray slit system, a scanning table for subject positioning, two fluorescent x-ray detectors with their X-ray collimator, and two pin-diode detectors for incident X-ray and transmission X-ray data. The white X-ray beam was monochromatized to 37 keV X-ray energy. The monochromatic X-ray was collimated into a various size of pencil beam (0.1-1 x 0.1-1 mm^2: horizontal and vertical direction). Fluorescent X-rays were detected in a high purity germanium (HPGe) detectors operating in the photon-counting mode and the HPGe detector was oriented perpendicular to the incident monochromatic x-ray beam. The data acquisition time of the HPGe detector for each scanning step was set 5-s.

Object was scanned in 0.1 - 1-mm translation and 1.2 - 12degree rotation over a range of 180 degrees. The 10-mm in diameter acrylic phantom filled with various concentration of iodine solution to determine the absolute content in biological object. FXCT images of heart and brain fixed by formalin were obtained after injecting non-radioactive iodine labeled agents (BMIPP and IMP).

The present experiment was approved by the Medical Committee for the Use of Animals in Research of the University of Tsukuba, and it conformed to the guidelines of the American Physiological Society.

Results and discussion

Iodine inside the phantom and living mice brain were clearly imaged by FXCT at a 0.25 mm spatial resolution with a 0.5 mm slice thickness [7]. Iodine labelled agent within formalin fixed brain and heart was also imaged clearly. Heterogeneous BMIPP uptake that reveals the impairment of myocardial fatty acid metabolism was shown by FXCT at a 0.1 mm spatial resolution in the cardiomyopathic model hamster [9,10] (Fig.1). FXCT enabled to assess the functional information using various types of labeling agents.

References

1. Takeda T, et al. Proc. SPIE 1996; 2708: 685-695
2. Yuasa T, et al. IEEE trans. Nucl. Sci. 1997; 44: 54-62
3. Rust GF, Weigelt J. IEEE Trans.Nucl.Sci. 1998; 45: 75-88
4. Takeda T, et al. Nucl. Instr. Meth. 2001; A467-468: 1318-1321
5. Yu Q, et al. J. Synchrotron Rad. 2001; 8: 1030-1034
6. Takeda T, et al. Proc. SPIE 2002; 4503: 299-309.
7. Takeda T, et al. Proc. SPIE 2004; 5535:380-391
8. Takeda T, et al. AIP Proc. 2004; CP705: 1320-1323
9. Thet-Thet-Lwin, et al. Jpn .J.Nucl.Med.2004; 41:377
10. Thet-Thet-Lwin, et al. Proc. APCMBE 2005: PA-3-34

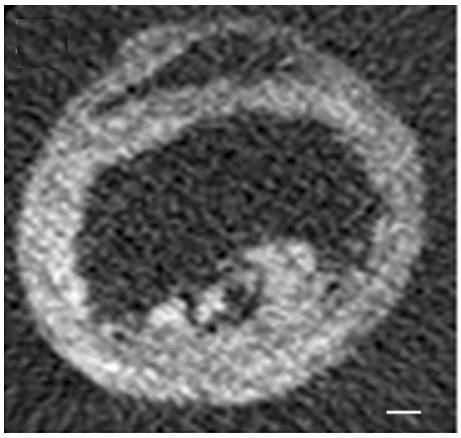

Figure 1 A I-127 BMIPP myocardial fatty acid metabolic image of a cardiomyopathic hamster obtained by FXCT. Bar =1 mm