Small Animal Whole Body Radio-fluorescence Tomography: A Pilot Study

Kun Wang[1,2], Wenting Shang[1], Yushen Jin[1], Jie Tian[1,2,*]

1. CAS Key Laboratory of Molecular Imaging, Institute of Automation, Chinese Academy of Sciences, Beijing, 100190, China.

2. Beijing Key Laboratory of Molecular Imaging, Beijing, 100190, China.

*Corresponding author: Email: tian@ieee.org, Tel: 86-10-82628760; Fax: 86-10-82628760

Objectives

Positron emission tomography (PET) and fluorescence molecular imaging or tomography (FMI or FMT) are commonly used for *in vivo* small animal imaging in the visualization of biological processes and events at functional or molecular levels. However, PET suffers from low resolution partly because of the physical limitation of γ detectors, while FMI is interfered by the high background noise generated from scattered excitation light and auto-fluorescence. In this study, we were aimed to develop a new small animal whole body tomographic imaging technology, named radio-fluorescence tomography (RFT), which utilized γ radiation excited fluorescence in a specially designed calcium tungstate film to achieve three-dimensional imaging of the radioactive tracer inside a small animal body.

Methods

We developed a RFT system that consisted of a high sensitive charge-couple device camera (EMCCD, Andor DU888+, UK), a radiation-to-fluorescence film, an optical filter, and a rotation platform (Figure 1a). The film was made from calcium tungstate in order to convert the γ radiation emitted from radioactive tracers into red light fluorescence, and designed as a cylindrical chamber to cover an imaging object. The EMCCD captures the fluorescent signal on the surface of the film from 360-degee. Then, the imaging object was scanned by a micro-CT system to obtain its anatomical structure. After that, a new iterative 3D reconstruction algorithm was designed to visualized the 3D bio-distribution of the radiotracer inside the object body. The RFT system was validated through a series of phantom and *in vivo* small animal studies by using the ^{18}F-FDG.

Results

The preliminary results of the phantom experiment demonstrated that the RFT system can achieve very high signal-to-noise ratio (SNR > 50) with very low radioactivity (1 μCi), because the film can efficiently covert the extremely high energy γ radiation into low energy fluorescence, and there was no excitation light, hence no background scattering and auto-fluorescence. The resolution was about 1 mm, which was better than the conventional small animal PET. The *in vivo* results of the two tumor-bearing xenografts also proved that RFT can successfully visualize the 3D bio-distribution of the ^{18}F-FDG in side tumor lesions (Figure 1b).

Conclusions

The RFT system can achieve small animal whole body imaging and visualize the ^{18}F-FDG distribution in 3D. It holds great potential in providing *in vivo* tomographic images with better resolution and SNR than conventional PET and FMI.

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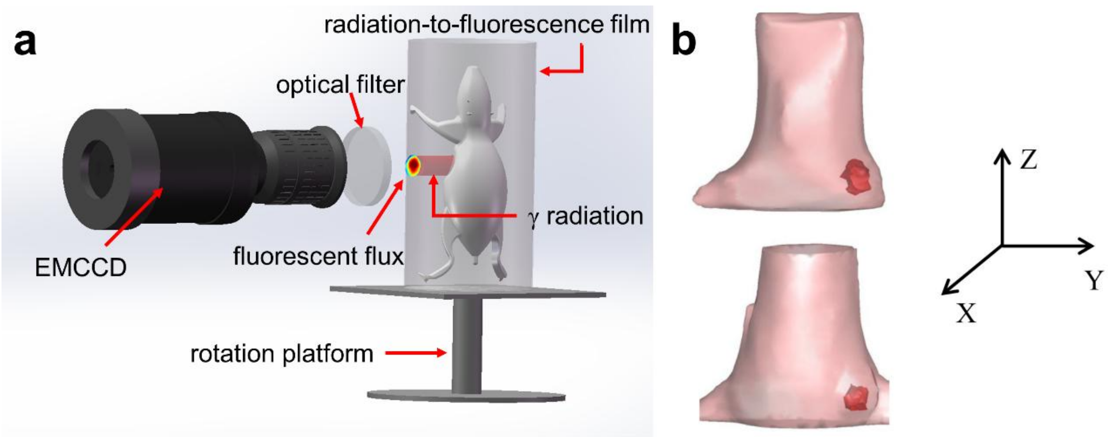

Figure 1. The RFT imaging system and its preliminary *in vivo* images. (a) The illustration of the main components of the RFT system. (b) The 3D rendering of the reconstructed RFT images for two xenografts, which indicates the ^{18}F-FDG accumulation inside tumor lesions.