Development of Endoscopic Radiation Probe for fusion imaging with MRI

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Introduction

Recently Endoscopy and X-ray have been used broadly in diagnostic tests for digestive organs. However these tests are not functional and detectability of early stage cancers depends on the experience of the radiologist. We propose a new fusion imaging method combining MRI and the newly developed endoscopic radiation probe (ERP). The ERP is inserted into the esophagus or the large intestine. It enables us to make an initial diagnosis of cancer using ^{18}F-FDG. Since the ERP prototype contains in part conductive materials, a non-conductive dummy probe having a MRI marker was prepared for accurate registration of both images. In our initial study, ERP performance was characterized by the use of a point source phantom and a thorax phantom. Visibility of the MRI marker was clearly identified by a 3D FSE sequence in the baby pig study.

Materials and Methods [1]

The ERP (Figure 1), which consists of a plastic scintillator and flexible optical fibers, has an outer diameter of 8 mm and its length is around 1 m. The ERP is automatically pulled back by a microprocessor-based controller so that we can accurately control the retrieval distance. The scintillator is evenly divided along its radial direction. The outer section detects both beta and gamma rays, while the inner one detects only gamma rays due to the shielding material between sections. This structure helps us eliminate various types of background noise (mostly gamma rays) by the subtraction of both signals. Therefore the ERP extracts only beta rays from closely located source points such as the ones in early stage cancers. The signal from each scintillator is evenly divided to two bundles of optical fibers and amplified by photomultipliers. Applying a coincidence measurement technique for each count results in removing the noise from electrical circuits and fibers. In our experiments, three aliquots of various concentrations of a radio labeled compound solution (1.2, 3.8, 16.1 kBq of ^{18}F-FDG) were put into the holes (5 mm diameter, 3 mm depth) that we used as source points. The spatial resolution and sensitivity of the ERP were investigated for these sources. In a further experiment, we implemented a dummy probe (Figure 2) , which consists of a vinyl chloride tube and an acrylic head with holes used as MRI markers. Both have different shapes. On one hand, we have a decentralized cylindrical cavity (Figure 3A), and on the other hand we have a laterally-faced cavity (Figure 3B). Both cavities were filled with a liquid solution (measured for T1 = 1500 ms). This enabled us to distinguish the angular direction of the ERP faces.

Figure 1 Endoscopic Radiation Probe

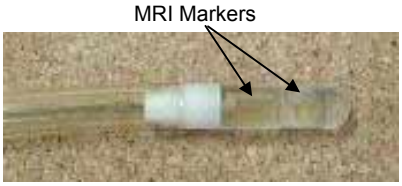

Figure 2 Dummy Probe

Results

A typical response was observed as shown in Figure 4. The upper curve is the detected signal from the outer scintillator which showed a baseline increase due to the gamma rays radiated from the thorax phantom. This is the net result before subtracting signals from the inner and outer sections of the scintillator. After subtracting both signals, the baseline was decreased and signals for 3.8 kBq and 16.1 kBq level point sources were clearly distinguished. However it was difficult to identify the signal for 1.2 kBq under the conditions used. While computing these data, the sensitivity for ^{18}F was 18.4 cps / kBq. Distance between the scintillator and the point source was around 0.4 mm. Figure 5 shows a MIP image of the dummy probe constructed from 3D FSE data acquired in the experiment. The shape of the MRI markers can be seen well enough, and they allow us to identify the radial direction of the dummy probe.

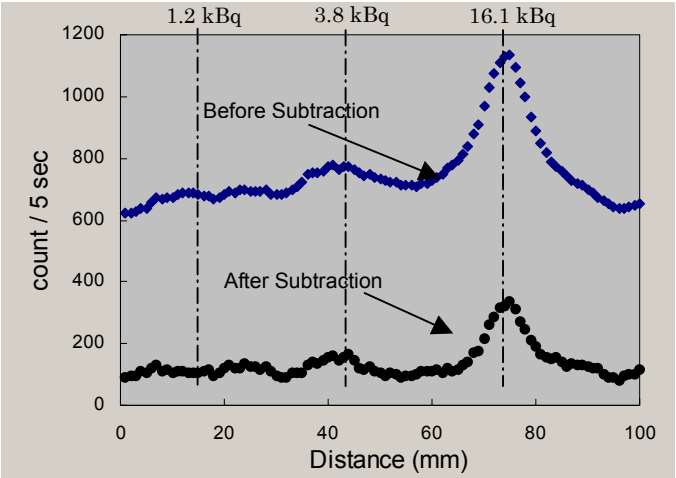

Figure 4 Response of ERP

Discussion

We demonstrated that the ERP had sufficient sensitivity for detecting beta rays from the labeling material in its proximity, which can be used together with MRI images for more accurate detection. In conclusion, fusion imaging using ERP and MRI data is valuable for diagnosis of early stage cancers in digestive organs.

Acknowledgment

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Reference

[1] T. Mukai et. Al, Eur J Nuc Med Mol Imaging (2004) 31: 1299-1303

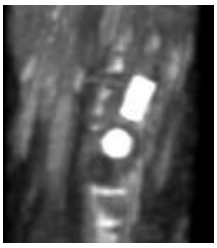

Figure 5
MRI marker image

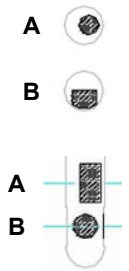

Figure 3
Cross section of MRI marker. Upper diagram is cross section of lower diagram A and B.