AN EXPERIMENTAL STUDY OF THE FEASIBILITY OF SIMULTANEOUS MRI AND SPECT IMAGING

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Purpose:

We had previously shown the MR compatibility of CZT based single photon detectors and associated nuclear data acquisition electronics [1]. The purpose of the present work was to study the feasibility a combined MR- SPECT system operating inside a 4T MR system for dual-modality MR-SPECT imaging. The current investigation included a study of the effect of SPECT detector/collimator system on the MR images (MRI) as well as the effect of MR on SPECT imaging and the feasibility of simultaneous MR – SPECT imaging.

Methods:

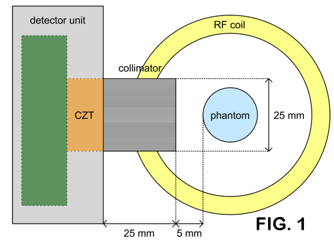


FIG. 1

In order to simulate an experimental SPECT system that would work inside an MR scanner we constructed a mini-version of such a system using a 1x1 inch^2 (16x16) pixellated CZT detector [1] in conjunction with the same size parallel –hole collimator made of lead (Pb). The collimator/detector assembly was inserted into a custom dual modality RF coil [2] for simultaneous imaging. The nuclear electronics were kept outside the scanner room while all the wires were passed through the penetration panel with appropriate filtering. The detector assembly was rotated around the object to acquire 30 equally spaced angular views around 360-deg for SPECT. From each nuclear projection image 3 rows were selected to make a 4.76mm slice in the reconstructed image. The data acquisition time for each scintigraphic projection image was 1.5 min. The system is shown in Fig.1. The MR pulse sequence parameters were: 2D- T1 Weighted Spin Echo, TR/TE=500/20ms, matrix = 128x128, FOV = 40x40mm, thickness=4.0mm, NEX=2, BW = 33.3 kHz. The number of slices was 7 with no gap. Parallel beam filtered back-projection algorithm was used for the SPECT reconstruction that was interpolated to the same matrix size as the MRI viz. 128x128. Each projection image was normalized by a flood image obtained at the same view to take into account of the Lorentz effect due to the magnetic field and to correct for detector non-uniformity. A center of rotation correction due to the Lorentz effect was also applied to each projection after the flood field correction. In order to test the effect of the operating MR system on the pulse height spectrum obtained with the CZT detector we measured the energy spectrum (PHS) of Tc-99m inside the magnet with and without the MR system being operational. We had previously shown that the static magnetic field had no effect on the PHS [1]. Two multi-modality phantoms made of Plexiglas were filled with a paramagnetic solution (Gd-DTPA) and 1 mCi of Tc-99m for sequential or simultaneous imaging. The first phantom was a hollow cylinder with an inner diameter of 22.5mm and a length of 82mm (uniform phantom). The second phantom was an identical cylinder that had 3 Plexiglas rods with 4.8mm diameter each separated from each other by 9.6mm center-to-center for resolution measurement in the reconstructed images (resolution phantom).

Results:

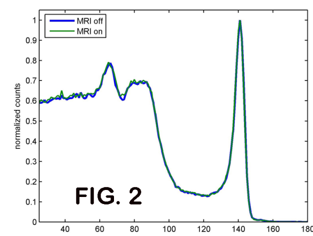
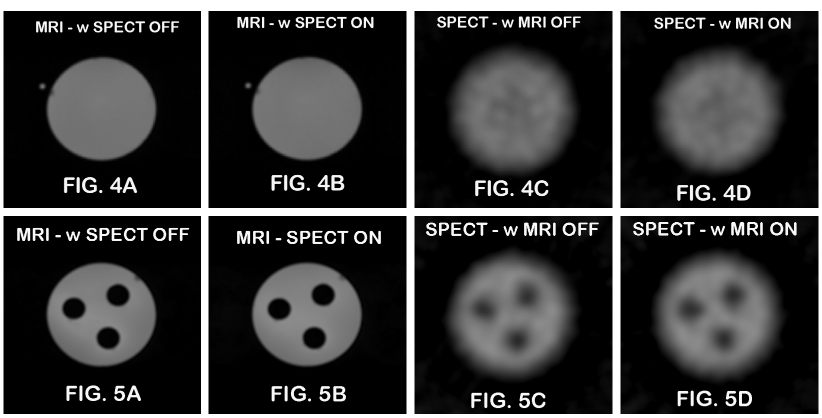


Figure 2 compares the PHS of Tc-99m obtained inside the 4T magnet with and without the MR system performing scanning. It is seen that the two spectra are identical and thus an operating MR system has no effect on SPECT data acquisition. This implies that it should be possible to acquire simultaneous MR and SPECT images with such a system. Figure 4 shows the MR and SPECT images of the uniformity phantom: A) MRI while SPECT off; B) MRI with SPECT on; C) SPECT while MRI off; and D) SPECT while MRI on. A close inspection of Figures 4.A and 4.B and Figures 4.C and 4.D shows no observable degradation from simultaneous operation of MR and SPECT data acquisition. Figure 5 shows the MR and SPECT images of the resolution phantom: A) MRI while SPECT off; B) MRI with SPECT on; C) SPECT while MRI off; and D) SPECT while MRI on. Again we do not observe any interference of MR on SPECT and vice versa.



Discussion:

The work presented here demonstrates experimentally the feasibility of constructing an MR compatible SPECT scanner that could be used for acquiring spatially and temporally co-registered MR and SPECT images that would be of great significance in molecular imaging [3]. The energy spectrum shown in Fig. 3 clearly demonstrates that one collect nuclear imaging data while the MR scanner is acquiring MRI. Figures 4 and 5 show that the spatial resolution in the SPECT images is poor compared to the MRI in the current setup. This is due to the fact that a parallel-hole collimator was used in front of the SPECT detector. However, as we have shown previously [4] it is possible to use the high-resolution MR images as a priori information in the SPECT reconstruction for improving the spatial resolution. Additionally the use of multi-pinhole collimators instead of the parallel-hole collimator would also help improving the SPECT spatial resolution [5].

References:

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