Feasibility Study of MREIT in Clinical Applications

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Introduction Several *in vitro* studies have shown that the electrical impedance of malignant tissues is significantly higher than those of normal and benign tissues. Therefore, impedance imaging has the potential as a diagnostic tool in cancer. Magnetic Resonance Electrical Impedance Tomography (MREIT) is a technique that is used for imaging impedance distribution inside an object noninvasively [1]. In MREIT, an external current is injected into the object and magnetic field perturbations due to this current are measured. Impedance images can be formed from these measurements using various reconstruction algorithms.

In MREIT, increasing injected current results in higher SNR in the measurements, leading to improved quality of the reconstructed images. However, safety regulations impose a limit on the total current that can be injected into a patient [3, 4]. Although a human study with 9mA is reported [2], the injected currents in MREIT should not exceed a few hundred microamperes.

Experimental Setup The test phantom was prepared using a hollow acrylic cylinder with an inner diameter of 65mm, which was filled to a height of 68mm with 0.1g $CuSO4\text{-}5H_2O$, 1g NaCl and 2g agarose per 100ml water solution. Inside this cylinder, two smaller cylindrical shells of 8.8mm diameter were placed to simulate electrically insulating regions. Three copper strips each 3mm wide were placed equidistant to each other and used as electrodes to inject current. The phantom was placed within a 4T MRI system coaxially with the magnet. A schematic of the phantom is shown in Fig. 1.a.

The data were collected for two current injection profiles, using electrode pairs A & B and A & C, respectively (Fig. 1.a). For each profile, a bipolar current pulse with a 200µA amplitude was injected into the phantom, and the data were acquired using with standard spin echo method with parameters: Tc = 37.5ms, TR = 500ms, TE = 50ms, slice thickness = 5mm, FOV = 80cm, data matrix = 64×64, BW = 33.3kHz, and NEX = 32 [4].

Results For reconstruction, a circular finite element mesh containing 2048 triangular elements was registered to the phantom. Then, magnetic flux density measurements were calculated from the phase images. Data from the two injection profiles and no current data were used in sensitivity matrix method to reconstruct the conductivity images [5]. Tikhonov regularization and 6 iterations were used in the reconstruction and the resulting conductivity image is shown in Figure 1.b. The average relative conductivities in background and insulator regions were measured as 1.04 and 0.193, respectively.

Conclusions We have previously reported MREIT results with 100µA currents, in which a smaller and thinner disc phantom was used (d=4.4cm, 1 cm thick) [7]. That confined the currents into small and shallow volume, improving the SNR. Nonetheless, it was the first report of an MREIT study at biologically safe current levels. In the present study, the conductivity images were obtained with 200µA injected currents from an object with dimensions closer to those that can be encountered in human applications. It should also be noted that the total injected current of 200µA is distributed uniformly along the whole length of the phantom, resulting in approximately 14.7µA flowing inside the conductive imaging slice. Therefore, we have demonstrated that MREIT studies that meet safety regulations is feasible for human applications.

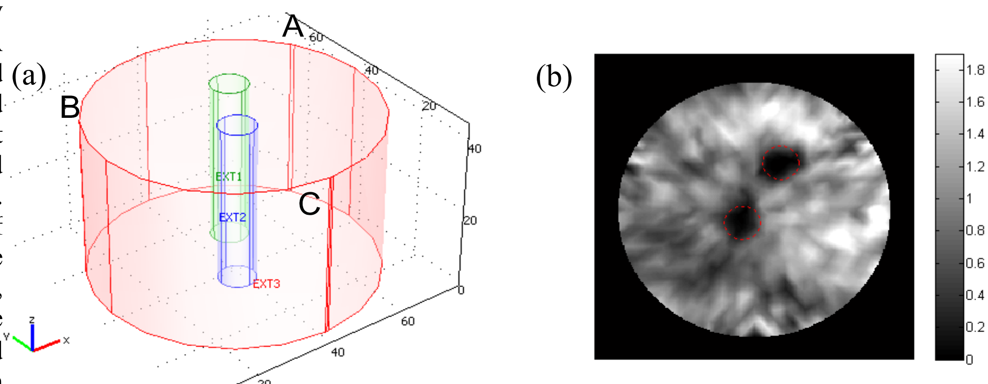

Figure 1. (a) schematic of the test phantom, (b) reconstructed conductivity image of test phantom

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