Magnetic Resonance Electrical Impedance Tomography of Neural Activity at 11.75 T

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Introduction

Magnetic resonance electrical impedance tomography (MREIT) seeks to generate high resolution maps of conductivity by measuring the change in magnetic flux density distribution within a volume after injecting an externally supplied current [1]. Because this change is dependent on external current, one of the present hurdles to *in vivo* implementation is to reduce the amount of current injected to a physiologically tolerable level while maintaining the overall quality of the conductivity map [2]. To overcome this restriction, ultra high magnetic fields can be applied to boost the signal-to-noise ratio and increase sensitivity to field perturbations [3].

Experimental

In this study, phantom (artificial seawater; ASW) and ganglion studies were conducted at 11.75 T. Abdominal ganglia were dissected from living *aplysia Californica*. Immersed in ASW doped with Omniscan, a ganglion was placed within a specially constructed 4-mm chamber with four ports for the injection of current. After placement in a 10-mm birdcage coil, MREIT scans were acquired using 2D multi-slice spin echo (SE) sequences with TE/TR=14/330 ms, slice thickness = 500 μm, and in-plane resolution = 70x70 μm. Synchronous with the SE acquisition, a 1-mA current was injected for 3 ms per lobe (6 ms total per scan) across paired ports so that ΔBz maps could be generated. Following initial MREIT scans, a KCl solution was injected to induce excitotoxicity in the ganglion. Subsequent MREIT scans were acquired to assess changes in neural activation (**Figure 1** a-d).

Results

Significant activation was observed within the isolated ganglion during current injection that was not observed in its absence. The addition of excitotoxic KCl (60 mM) enhanced the neural activation, which can be observed as an increase in the variance of the phase localized within the ganglion in the phase difference image. With death, the observed activation within the ganglion dissipates with time, ultimately leading to a zero level over an extended time course (18 hr). The average standard deviations in the accumulated phase difference during pre-KCl, post-KCl and death conditions were (2.11±0.33)°, (2.75±1.03)° and (1.27±0.13)°, respectively, indicating significant activity levels under the two excitatory conditions compared to the standard deviation in ASW regions outside ganglia (0.79±0.12)° for $p<0.05$. Phase variation in ganglia increases with KCl but decreases with death.

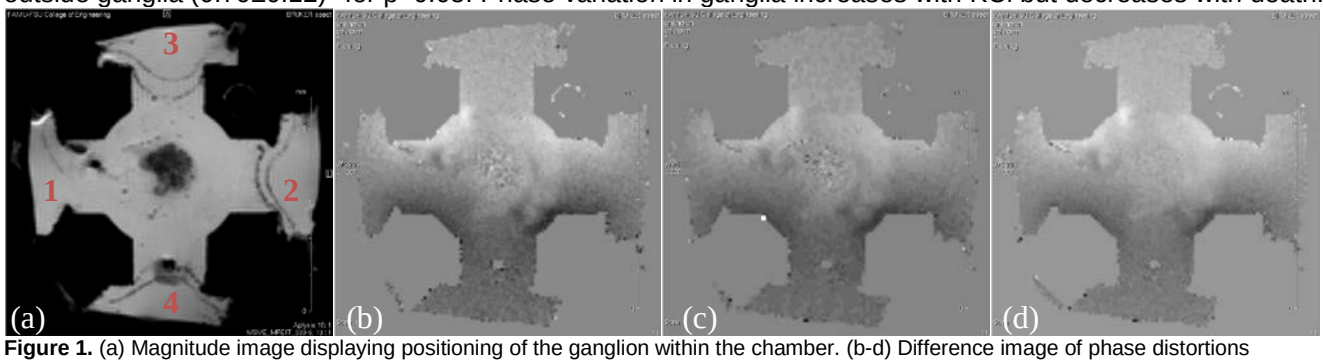

Figure 1. (a) Magnitude image displaying positioning of the ganglion within the chamber. (b-d) Difference image of phase distortions generated by injecting current through Ports 1-2: before (b) and after (c) KCl administration and after the ganglion has been allowed to die (d).

Conclusions

High field MREIT offers sensitivity to neural excitation in vitro by means of altered conductivity likely resulting from active ionic channels. As such, this work represents one of the first evaluations of MREIT as a direct functional imaging modality to assess neural activation nondestructively and noninvasively.

Acknowledgements

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References

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