Cerebral perfusion imaging using EIT

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Abstract: Imaging of cerbral perfusion is understood to provide rich information on cerebral processes. This study explores whether EIT is able to image perfusion in the brain. In a single rat, a bolus of hypertonic saline was introduced into an arterial catheter during two activity states, and EIT images reconstructed. Results suggest that changes in perfusion pattern are visible in EIT images.

1 Introduction

In functional MRI imaging, the Blood-oxygen-level dependent (BOLD) signal allows imaging of the "hemodynamic response", a process by which active neurons with higher metabolic rates induce delivery of additional blood (perfusion). Cerebral imaging using fMRI now plays an important role in functional studies involving the brain.

EIT has been used to image perfusion in the lungs using a venous injection of a bolus of hypertonic saline[2], where the contrast agent flows through the heart and then the lungs increasing conductivity in proportion to blood flow. We were motivated to explore whether EIT is able to measure perfusion in the brain, as this could potentially provide rich functional imaging possibilities, especially given EIT's ability to image small volumes with high temporal resolution.

To explore this possibility, a pilot experiment was conducted in a single rat. EIT measurements were performed during injection of the contrast bolus in two conditions to provide a within-subject control.

2 Methods

A single white Sprague-Dawley rat was anesthetized and ventilated. A craniotomy was performed and an array of 57 EIT electrodes placed on the cortical surface. Using the Scouse-Tom EIT system[1], data were collected at 5 frames/s and a total of 903 stimulation/measurement pairs acquired. A heuristic protocol aimed at maximizing sensitivity throughout the cortex was implemented and current of amplitude 50μA and 2 kHz was injected.

A contrast bolus of 10% NaCl (w/v) of size $500\,\mu$L was used. First, the bolus was injected through a venous injection via the femoral vein. As expected, no clear cerebral perfusion signal was seen, likely because the conductivity contrast became diffuse while travelling through the pulmonary vasculature. Next, an arterial catheter was inserted via the femoral artery and placed at the aortic arch (as verified by the pressure waveform). EIT recording was initiated before the arterial bolus injection for two conditions (repeated twice): (C) control condition (no stimulation) and (S) electrical stimulation of the forepaw (and thus the S1 forepaw somatosensory cortex)[3].

3 Results

Time-difference EIT images were reconstructed using a one-step GN algorithm and the slices of the volumetric image or the cortex studied as a function of time (Fig. 1). In all recordings, there was a clear signal which corresponded to the expected arrival time of the bolus.

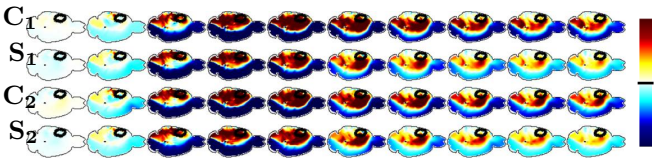

Figure 1: Time sequence of EIT images of a horizontal slice (Red $\uparrow\sigma$, Blue $\downarrow\sigma$), from left to right; images spaced by 600 ms. C_1, C_2) control (no stimulation). S_1, S_2) with forepaw stimulation.

In order to explore whether EIT detected differences between groups, the maximum images are shown in Fig. 2. Some differences in the spatial pattern appear visible, and are repeatable between the repeated protocols.

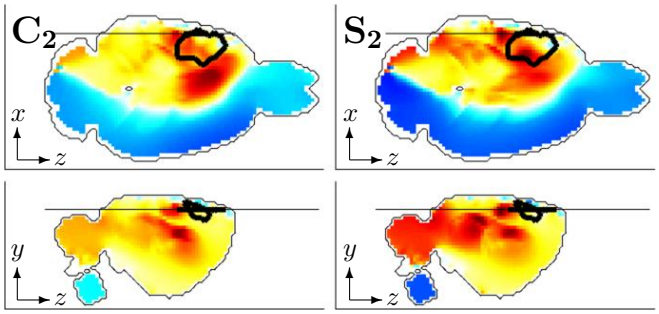

Figure 2: EIT images of maximum signed voxel value for C) control, and S) forepaw stimulation. Region outlined in black is the S1 forepaw cortex. Coronal (top) and Saggital (bottom) slices shown.

4 Discussion

Our goal was to explore the possibility of creating EIT images of cerebral perfusion using an injected bolus contrast. Results in a single rat are show consistent images corresponding to the expected arrival time of cerebral perfusion. Additionally, there are interesting spatial differences between the control and stimulation protocols which are suggestive of underlying functional changes.

References

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