120-channel electrode arrays for rat brain: Towards 3D EIT imaging

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Abstract: EIT has much potential in many brain imaging applications demonstrated through animal experiments with a small epicortical 30-channel array. Spatial resolution can be improved by using a larger array to cover most of brain. A 120-channel electrode system was fabricated and successfully implanted covering c.90% of brain, and EIT data was successfully recorded.

1 Introduction

EIT has the potential to provide a radically new portable inexpensive way to image brain function in conditions like stroke or epilepsy, blood volume changes during evoked responses or even millisecond neural depolarisation during normal activity. EIT has been successfully used in our group previously to image impedance changes related to these conditions on the rat brain using a 5 x 7 mm 30-channel epicortical planar electrode array, custom made from stainless steel foil on silicone rubber [1]. This gave a resolution of 200µm in cerebral cortex but modelling indicated that more electrodes were needed to achieve satisfactory resolution throughout the entire brain (Fig. 1). The purpose of this work was to develop and test electrode arrays able to apply 120 electrodes to cover most of the rat brain. We evaluated their suitability for surgical insertion and impedance recording.

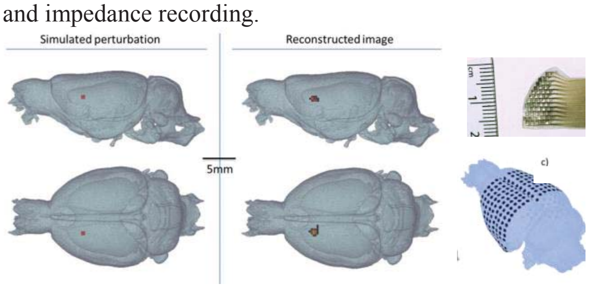

Figure 1: Simulated images reconstructed for a 1% impedance decrease, in the hippocampus using a 6M element mesh for the forward and 500k for inverse problem. Changes throughout the rat brain using 120 electrodes could be reconstructed with an accuracy of <500µm.

2 Methods

2.1 Electrodes

Electrodes were fabricated using laser-cut stainless-steel foil sandwiched between two silicone rubber layers, which was our preferred technique after a previous study comparing two different methods for electrode fabrication [2]. Electrodes were 0.6mm in diameter and 1.3mm apart. One array consisted of 60 channels and used for one hemisphere on the rat brain while its mirrored copy used on the opposite hemisphere.

2.2 EIT recordings

Impedance change recordings associated with evoked potentials were undertaken in an anaesthetised rat with forepaw and whisker stimulations. Two of the 60-channel arrays were implanted directly on exposed cortex. EIT was recorded using a Keithley 6221 current source and Biosemi A/D EEG system.

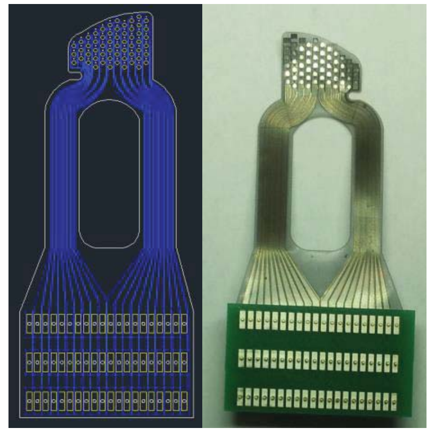

Figure 2: Image of CAD drawing of the 60 channel array (left) and a photograph of fabricated array (right)

3 Results

Electrodes were suitable for surgical application and covered c.90% of the brain. Electrode impedances were all < 800Ω at 100Hz. Satisfactory impedance changes and evoked potentials could be recoded on all channels.

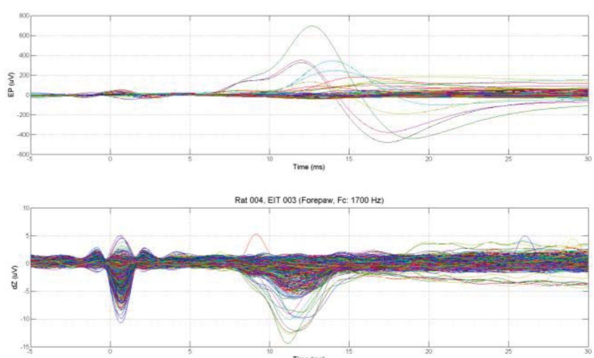

Figure 3: Top panel: recorded evoked potentials, Bottom panel: the corresponding impedance change; Different channels are represented by the different coloured lines.

4 Discussion

A 120-channel electrode system was successfully fabricated and design was optimised for successful and easy surgical implantation. Impedance changes were successfully recorded. Work in progress is to obtain 3D images from recorded impedance changes.

References

[1] Oh et al. *Medical & biological engineering & computing*, 49(5), pp.593–604. 2011.

[2] Koronfel MA et al. Submitted to *Physiological measurements* special issue 2014.

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