Abstract

We present an electro-optical device that measures near-infrared optical signals from peripheral nerves during electrical stimulation. Our previous studies have shown that these optical signals peak on a distinctly different timescale (~100 ms) as the BOLD signal due to systemic recruitment of blood flow (~3-5 s) and the fast scattering signal due to neuronal swelling. This timescale difference signifies that the 100 ms optical signals are not originating directly from the nerve activation, but are a mediated response to neuronal activation. Our studies on the peripheral nerves provide some insight into the origins of the fast optical signal, as well as other fast electrical signals (~10-100 ms) that can be detected in in vitro related peripheral studies [4]. These electrical activities are correlated with a hemodynamic response to deliver metabolic supplies through neuronal coupling.

Introduction

Increased central blood flow due to neuromotor activation has been studied extensively at the second time scale using the BOLD signal in fMRI [2] and using near-infrared spectroscopy [3]. There are also fast electrical signals (~10-100 ms) that can be detected in in vitro related peripheral studies [4]. These electrical activities are correlated with a hemodynamic response to deliver metabolic supplies through neuronal coupling.

Fast optical signal in membrane potential of neuron cell cultures

Studies in neuron cell culture [9] and in vivo [9], and non-invasive measurements in the human brain [7.8] (Fig. 5) have recorded fast optical signals around the same time scale (~100ms) as the post synaptic potential measured in the brain. However, the biological mechanism and the practical feasibility of measuring fast optical signals associated with brain activation through the intact human head are under debate.

Current Optical Probes

The peripheral nervous system provides a potentially simpler and more robust model to study the optical signals in response to electrical stimulation of selected nerves. The electrostimulation of the sural nerve provides a sensory nerve action potential (SNAP) a few milliseconds after the electrical pulse. We have studied the optical response associated with the electrical stimulation of the sural nerve.

Optical Recording - Modulation frequency: 110MHz - Sampling rate: 50 Hz - Source-detector distance: 1.5 cm - PMT: Photomultiplier Tube

EES delivers electrical stimulation and records sensory nerve action potentials

Results

We have non-invasively measured optical responses due to electrical stimulation of peripheral nerves on the order of 0.1 ms change in intensity. The signals have been characterized using temporal, spatial and angle dependent analysis in an effort to develop an early diagnostic tool for diabetic neuropathy.

Conclusion

We have non-invasively measured optical responses due to electrical stimulation of peripheral nerves on the order of 0.1 ms change in intensity. The signals have been characterized using temporal, spatial and angle dependent analysis in an effort to develop an early diagnostic tool for diabetic neuropathy.