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HYPER-SPECTRAL IMAGING OF BRAIN ACTIVITY DURING FUNCTIONAL NEUROSURGERY OF PATIENTS WITH EPILEPSY

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In epilepsy surgery the focus of epilepsy should be delineated as accurately as possible to minimize damage to critical brain structures. Conventional focus localization techniques include scalp EEG, MEG, SPECT, and PET. These are all indirect methods, i.e. the focus has to be estimated, co-registered to MRI and relocated to the cortex during surgery. In this study we explore the use of a hyper-spectral camera system for directly seeing oxygenation changes in the cortex.
The first epilepsy patient had recurring seizures every five minutes with tonic spasms in one hand, continuing for 24 hours a day. MR images and intracranial EEG recordings demonstrated seizure onset in the primary motor hand area. After removing the intracranial electrode grid, the exposed cortex was imaged using a hyper-spectral camera mounted to the surgical microscope. During a 7 minute scan, a group of 4 wavelength images was captured every second. By calculating the oxy-hemoglobin concentration, a local increase in oxygen was seen in the motor cortex of the hand, corresponding to the intracranial EEG findings. After multiple subpial transections in this motor area, clinical seizures abated.
For a second epilepsy patient the hyper-spectral setup was replaced by a system with a higher image acquisition rate (from 3 frames/s to 16 frames/s). The liquid crystal tunable filter was replaced by a tunable LED based light array system ranging from ultra-violet to near-infrared. In this case 7 wavelength bands were monitored to visualize the changes in oxygenation across the cortex. Fourier analysis and oxygenation movies revealed unknown patterns around 6 times and 24 times per minute, while breathing was 12 times and heart rate around 58 times per minute.
In conclusion, we were able to monitor seizure activity in the cortex by directly observing local oxygen consumption. Apart from seeing the consequences of the seizure directly, unknown oxygenation patterns were seen across the cortex. This opens prospects of intra-operative function localization of sensory evoked stimuli, or, in the awake patient, of voluntary motor or speech activity.