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Analysis of Direct Recordings from the Surface of the Human Brain

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Recording electrophysiologic signals directly from the cortex of patients with chronically implanted subdural electrodes provides an opportunity to map the functional organization of human cortex. In addition to using direct cortical stimulation, sensory evoked potentials, and electrocorticography (ECoG) can also be used. The analysis of ECoG power spectrums and inter-electrode lateral coherence patterns may be helpful in identifying important eloquent cortical areas and epileptogenic regions in cortical multifocal epilepsy. Analysis of interictal ECoG coherence can reveal pathological cortical areas that are functionally distinct from patent cortex. Subdural ECoGs have been analyzed from 50 medically refractive pediatric epileptic patients as part of their routine surgical work-up. Recording arrays were implanted over the frontal, parietal, occipital or temporal lobes for 4-10 days, depending on the patient's seizure semiology and imaging studies. Segments of interictal ECoG ranging in duration from 5 sec to 45 min were examined to identify areas of increased local coherence. Ictal records were examined to identify the stages and spread of the seizures. Immediately before a seizure began, lateral coherence values decreased, reorganized, and then increased during the late ictal and post-ictal periods. When computed over relatively long interictal periods (45 min) coherence patterns were found to be highly stable ($r = 0.97$, $p < .001$), and only changed gradually over days. On the other hand, when calculated over short periods of time (5 sec) coherence patterns were highly dynamic. Coherence patterns revealed a rich topography, with reduced coherence across sulci and major fissures. Areas that participate in receptive and expressive speech can be mapped through event-related potentials and analysis of task-specific changes in power spectrums. Information processing is associated with local increases in high frequency activity, with concomitant changes in coherence, suggestive of a transiently active language network. Our findings suggest that analysis of coherence patterns can supplement visual inspection of conventional records to help identify pathological regions of cortex. With further study, it is hoped that analysis of single channel dynamics, along with analysis of multichannel lateral coherence patterns, and the functional holographic technique may allow determination of the boundaries of epileptic foci based on brief interictal recordings, possibly obviating the current need for extended monitoring of seizures.