Cerebrovascular interactions in the neonatal brain during seizures

H Singh[a,b], R Cooper[a,b], C.W Lee[a,c] , L. Dempsey[a,b], A Edwards[a,c], N Everdell[a,b], T. Austin[a,c] and J. Hebden[a,b]

[a]*neoLAB, the Evelyn Perinatal Imaging Centre, Rosie Hospital, Cambridge, UK*
[b]*BORL, Department of Medical Physics and Bioengineering, UCL, London, UK*
[c]*Neonatal Unit, Rosie Hospital, Cambridge University Hospitals NHS Foundation Trust, UK*

harsimrat.singh@ucl.ac.uk

Introduction: Seizures in the developing brain are poorly classified, frequently under diagnosed, are difficult to treat and are associated with poor neurodevelopmental outcome. Video-EEG is the standard approach to monitoring seizures, but has limited spatial resolution and provides little information on the potential mechanisms by which seizures could exacerbate brain damage. Diffuse optical tomography (DOT) provides hemodynamic information in the form of changes in concentration of de/oxygenated hemoglobin which can improve our understanding of seizures and the relationship between neural and vascular processes.

This paper presents novel simultaneous DOT-EEG data showing distinct hemodynamic changes which are temporally correlated with electrographic seizures.

Methods and Results: Simultaneous DOT-EEG studies were performed on a cohort of neonates (n=10) with suspected hypoxic-ischaemic encephalopathy (HIE) (mean gestational age of 40 weeks+3 days). An array that provides 58 DOT channels and contains 11 EEG electrodes was used in conjunction with the UCL Optical Imaging System and a Micromed clinical EEG system. In one infant with severe HIE, 7 seizure events were observed. A pronounced hemodynamic response remarkably

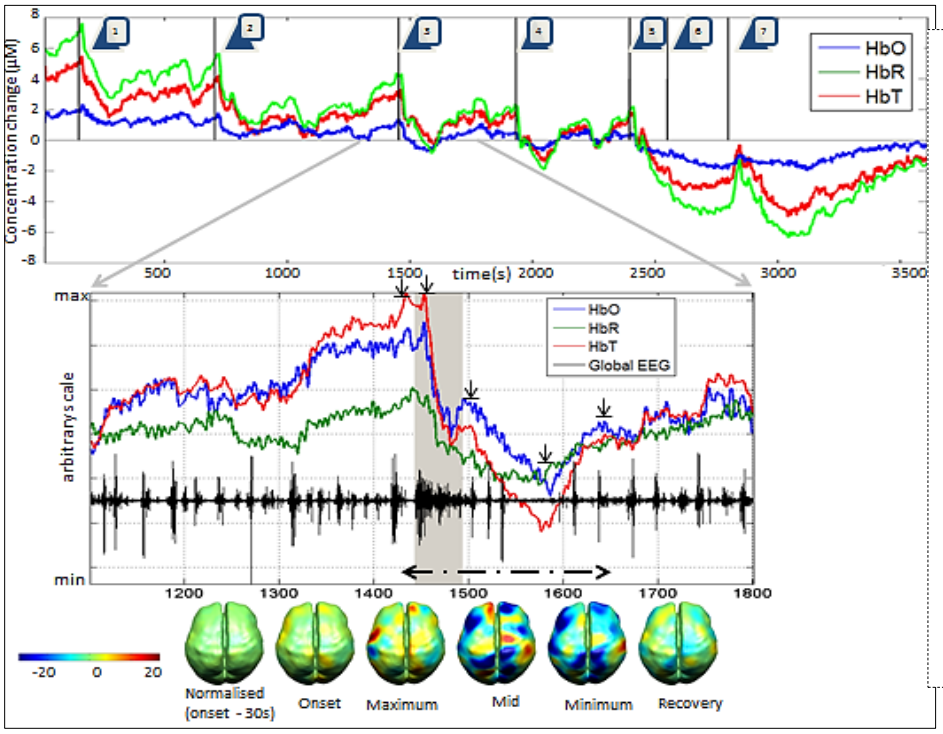

Figure: Seven seizure events are indicated on time course of the mean hemodynamic concentration changes. Seizure onset is depicted by vertical lines. Characteristic response for seizure shows onset, duration highlighted by the grey shaded area. A large surge in the EEG activity indicates the seizure event. A typical response with reconstructed images (HbT) at six distinct points highlights the response profile.

consistent across all 7 events was observed (See figure). The typical hemodynamic response is characterised by an increase in blood-volume just after the electrographic seizure onset followed by an extended decrease and slow recovery to a steady state. The reconstructed DOT images exhibit complex spatial dynamics reminiscent of animal studies, which show an 'inhibitory surround' phenomena associated with epileptic foci. These results highlight the wealth of physiological and clinical information that can be obtained using simultaneous DOT-EEG.