ASSESSMENT OF NEUROVASCULAR COUPLING IN NEONATES USING SIMULTANEOUS DOI AND EEG

L. Dempsey, C. Ward (1); N. Batey (1); J. Teoh (2); M. Grubb (2); J. Crowe (2); B. Hayes-Gill (2); N. Marlow (3); D. Sharkey (1); C.W. Lee
(1) University Of Cambridge, Department Of Clinical Neurosciences; (2) Cambridge University Hospitals Nhs Foundation Trust, Department Of Neonatology; (3) University College London, Biomedical Optics Research Laboratory

Introduction: Understanding the relationship between electrical and haemodynamic activity (neurovascular coupling) resulting from brain activation is an important prerequisite of functional brain imaging. An approach to studying neurovascular coupling in the newborn is to combine electroencephalography (EEG) with diffuse optical imaging (DOI). DOI uses near-infrared light, is non-invasive, and can produce both topo- and tomographic images of regional cerebral blood flow. The ability to elucidate healthy and pathological cortical activity using combined EEG-DOI could help better estimate future cognitive and motor deficits in premature and term-born infants.In this preliminary study we aimed to study resting state functional connectivity (RSFC) globally in the cortex of sleeping infants using combined EEG and DOI.
Patients and Methods: Eight babies born with a median gestational age of 37+3 weeks (range 35+1 – 41+5 weeks) were studied at a median gestational age of 38+3 weeks (range 36+2 – 42+2 weeks). All infants were recruited from the Neonatal Intensive Care Unit of the Rosie Hospital. Seven were healthy subjects or only had mild complications with no history of neurological pathology. The other, RSFC_006, showed burst suppression in line with hypoxic ischemic encephalopathy (HIE) during a clinical EEG scan at 1.5 hours of age. Subjects were scanned in their cots immediately after a feed and while quietly resting. The length of the scan typically lasted 30-60 minutes.A 13-channel EEG and continuous-wave DOI system with 16 sources and 16 detectors were used in parallel to acquire simultaneous data of neurovascular coupling. The EEG-DOI array was attached to the infant's head using a soft, skin-compatible cap that positioned each electrode, detector, and source relative to the 10-5 international cortical labeling system. The cap was designed to cover the entire surface of the head, including the frontal, parietal, temporal, and occipital lobes.Optical and EEG data were pre-processed and cleaned of motion artifacts. DOI data was bandpass filtered in the RSFC range (0.009-0.08 Hz) prior to time series correlation. Global signal regression (GSR) was used to eliminate noise in the optical data due to systemic physiology. Pearson's correlation coefficient r and z-scores were calculated for the time course of each channel in relation to every other channel. Channels were considered correlated when r > 0.5.

Table 1 - Subject Information

Subject Code	GA at delivery	GA at scan	Head circ. (cm)	Relevant clinical remarks
RSFC_001	36 1/7	39	33.5	Prematurity, duodenal atresia, ASD*, jaundice
RSFC_002	37	37 2/7	36.8	Healthy term infant
RSFC_003	38	38 4/7	35.5	Healthy term infant
RSFC_004	37 5/7	38 1/7	35.0	Healthy term infant
RSFC_005	35 1/7	36 2/7	31.8	Prematurity, IUGR†, RDS**
RSFC_006	38 1/7	39 4/7	33.9	IUGR†, jaundice, HIE‡ Grade 2, seizures
RSFC_007	41 5/7	42 2/7	35.5	Healthy term infant
RSFC_008	36	36 5/7	34.4	Prematurity

* = Atrial septal defect, † = Intrauterine growth retardation, ** = Respiratory distress syndrome, ‡ = Hypoxic ischemic encephalopathy

Results: Analysis of pilot optical data demonstrated connectivity maps in infant cortex. The region of the chosen seed, especially in frontal and parietal areas, typically correlated to other nearby channels and to homologous channels in the opposite hemisphere. GSR was found to be an effective method of reducing correlation false positives due to systemic physiology.
Conclusions: Our preliminary results imply that bimodal DOI and EEG recording can be a useful tool for investigating neurovascular coupling in infants at the cot-side. Further analysis of simultaneous optical and electric data from neonatal cortex could yield novel information about neurological connectivity and pathology in the developing brain. These results have the potential to help create a set of valuable imaging biomarkers for the management of infants with perinatal brain injury.