The Determination of Neonatal Brain Oxygenation Status by Near Infrared Technology

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Abstract

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Background: Persistent tissue hypoxemia or hyperoxemia frequently lead to multi-organ injuries. Specific brain activity is also associated with amplitude variations of oxy and deoxy hemoglobin (Hb). Diffuse optical tomography (DOT) using near infrared light at 760 and 830 nm can functionally explore the brain microcirculation.

Objective: The objective of our project is to measure variations in oxygen status in neonatal brain tissue with DOT.

Design/Methods: The imaging device has 30 optodes embedded in a silicone flap that is secured to the infant's head. Such measurements, combined with the image reconstruction, allows us to explore the dynamics of blood delivery and O2 extraction, and the influence of disease states. We monitor variations of oxy, deoxy and total Hb of the brain tissue under different conditions: awake/asleep, or +/- visual or auditory stimulation, on infants in the NICU.

Results: We performed a total of 12 DOT sessions on 9 infants who were stable or needed minimal O2 supplemention.

Image sections show that the deoxyHb concentration is recovered with significant regional and temporal resolution.

Graphs show that the respiratory (1.2 Hz) and vasomotor rhythms (0.2, 0.02 Hz) of the Hb concentration are recovered, with regional variations in the amplitude ratios.

Conclusions: DOT for bedside measurement of neonatal brain oxygen status is useful for preventing the exposure of infants to extreme oxygen swings. Our future aim is to determine whether tissue oxygen extraction is proceeding normally, without extreme swings in the Hb concentrations.

Background

Persistent tissue hypoxemia frequently leads to ischemic encephalopathy and multi-organ injuries. At the other extreme, morbidity induced by hyperoxic states may lead to bronchopulmonary dysplasia and retinopathy of prematurity.

Neonatal brain tissue oxygen status can be affected by the physiologic redistribution of blood flow during brain activity or by the disruption of blood and oxygen in pathologic circumstances. Specific brain activity is also associated with parallel amplitude variations of oxy- and deoxy-hemoglobin. Optical tomography of using near infrared (NIR) light at 760 and 830 nanometers allows the functional exploration of both deoxy- and oxyhemoglobin in the microcirculation of the cerebral cortex and in deeper-lying structures.

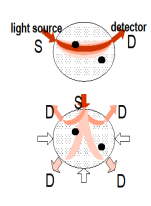
Objectives

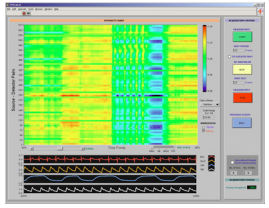
The objective of our project is use NIR-based Diffuse Optical Tomography to measure variations in oxygen status in neonatal brain tissue.

Methods

The infant brain imaging device uses NIR light with 30 optodes embedded in a silicone flap, which is secured with bands tied to the infant's head. Such measurements combined with the image reconstruction using specific software (NAVI: NIRx Medical Technologies, Glen Head, NY), allows us to explore the dynamics of tissue oxygen delivery and extraction and the corresponding influence of disease states. We monitor the baseline variations of oxy, deoxy and total hemoglobin of brain tissue during physiological states: awake vs. asleep, and the presence and absence of visual and auditory stimulation. After parental consent is obtained, the infants remain under constant supervision in the NICU throughout the procedure.

At present we did not attempt any comparisons with EEG, head CAT scan and MRI done for pathological /anatomical abnormalities.





Data

We performed a total of 12 Diffuse Optical Tomography sessions on 9 infants who were stable or needed minimal O_2 supplementation.

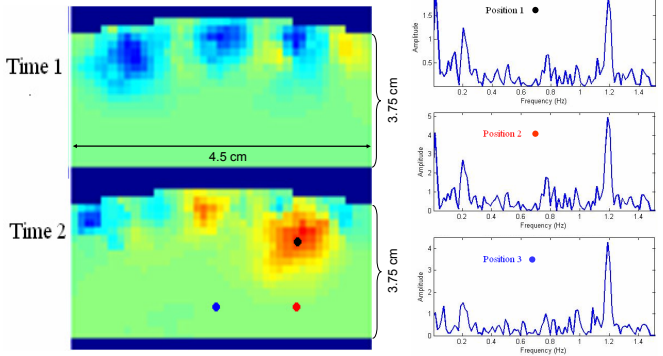
Image sections show that the deoxyhemoglobin concentration is recovered with significant regional and temporal resolution (Fig 1.)

Graphs show that the respiratory (1.2 Hz) and vasomotor rhythms (0.2, 0.02 Hz) of the hemoglobin concentration are recovered, with regional variations in the amplitude ratios (Fig 2.)

Results

Fig. 1 Hemoglobin concentration of coronal section of parietal lobe is recovered significant regional and temporal resolution.

Fig. 2 Regional variations in the relative amplitudes of autonomic and respiratory rhythms/frequencies.



Conclusions

Diffuse Optical Tomography for monitoring tissue oxygen status in the neonatal brain at the bedside may be an effective tool for forestalling the occurrence of extreme oxygen swings. Our future aim is to determine whether tissue oxygen extraction is proceeding normally, without extreme swings in the hemoglobin concentrations.

References

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