**Monitoring Neurocritical Patients With Diffuse Optical Techniques**

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**Introduction:** The immediate intervention and continuous monitoring of neurocritical injuries are essential to avoid more damage. In the neuro intensive care unit (NICU) clinicians usually rely on systemic physiological data readily available to decide on therapeutic strategies. There is an urgent need for the development of tools for assessing cerebral physiology non-invasively and at the bedside. Diffuse optical techniques have been shown to register brain physiology continuously and non-invasively [1], during hospitalization and also during surgery [2]. By shining light onto the scalp, it is possible to recover in real time the cerebral oxygen saturation ($StO\_{2}$), cerebral blood flow ($CBF$) and the cerebral metabolic rate of oxygen ($CMRO\_{2}$). Recently, we translated a novel homemade metabolic monitor ($M^{2}$) into the NICU [3]. In this work, we present a clinical application for this monitor as a bedside marker of brain injuries.

**Materials and Methods:** All measurements were performed with our metabolic monitor, which combines two diffuse optical techniques: diffuse optical spectroscopy (DOS) [4] and diffuse correlation spectroscopy (DCS) [5]. The system is also integrated with a neuronavigator system (VMTK) for real-time assessment of the injury location with greater accuracy. We present a case study of a subarachnoid hemorrhage (SAH) patient who was monitored with our optical system during the whole hospitalization period. The patient was admitted to the hospital with a SAH in the right hemisphere (confirmed by computed tomography, CT) and Hunt-Hess scale of 5. We monitored the patient with the metabolic monitor for approximately 1 hour per day on each hemisphere during the whole hospitalization period. All the systemic parameters, such as the mean arterial pressure (MAP), arterial oxygen saturation (SaO2), heart rate variability (HR) and respiratory frequency (FR) were monitored. No treatment decisions were made on the basis of the measured values, and all procedures were supervised by a neurologist.

**Results and Discussion:** On the second day after admission, when the hemorrhage was expanding, CBF in the ipsilesional hemisphere was an average of 20% higher than the CBF on the contra-lesional hemisphere, which is consistent with the CT hemorrhage diagnosis. The patient’s right hemisphere evolved to ischemia between the fourth and fifth days of hospitalization, as confirmed by an updated CT scan. On the sixth day of hospitalization, the metabolic monitor revealed significantly lower CBF (-56%) and CMRO2 (-54%) in the ipsilesional hemisphere, which is again consistent with the patient diagnosis. In the following days a slower decrease of flow and metabolism was observed, in comparison with the patient's state at the beginning of the experiment. This is consistent with the worsening of the patient. The patient eventually died on the ninth day of hospitalization, with CBF and CMRO2 indexes on the ipsilesional hemisphere 65% and 60% belowthe initial values, respectively.

**Conclusion:**  By comparing the hemodynamic physiology in the cortical region with the CT images for the case studied, our results suggest that diffuse optical techniques can reliably monitor the evolution of neurovascular injuries in real time, non-invasively and at the bedside. Our system is sensitive to brain injury and thus could be a helpful tool for the individualized monitoring of neurocritical patients.

**References:** [1] Mesquita, R. C. et al., J. of Biomed. Opt. (2013); [2] Busch, D. R. et al., Biomed. Opt. Exp. (2016) [3] Forti, R. M. 3rd BRAINN Congress, Campinas, Brazil (2016) [4] Mesquita, R. C. et al., Biomed. Opt. Exp. (2010); [5] Durduran, T. et al., Neuroimage (2014).