BEDSIDE MEASUREMENT OF CEREBRAL HEMODYNAMIC BIOMARKERS WITH FAST DIFFUSE CORRELATION SPECTROSCOPY

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The objective assessment and characterization of cerebral tissue health at the bedside is a difficult but highly significant problem in the acute care of strokes and other brain injuries. Observational limitations of current technologies, which are better suited for radiological snapshots rather than continuous monitoring of cerebrovascular health, limit bedside optimization/augmentation of care to subjective judgements of observed neurological deficits. In recent years, Diffuse Correlation Spectroscopy (DCS) has proven to be an increasingly popular non-invasive optical technique to solve this technological gap by directly measuring and monitoring deep tissue blood flow. Here, we highlight DCS’s utility as a clinical bedside monitor of acute CBF changes in patients affected with ischemic stroke. In addition, we highlight the development and application of new ‘fast’ DCS instrument that uses conventional DCS sources/detectors, and optimized software computations to measure blood flow ‘waveforms’ at measurement rates of 50-100 Hz. A direct consequence of this new CBF data type is the ability to characterize potentially chronic biomarkers of cerebral tissue health at the bedside. First, we employ the fast-DCS instrumentation to measure cerebral autoregulation (CVAR) dynamics. Cerebral autoregulation, which is impaired in the injured brain, refers to the mechanism by which cerebral blood flow (CBF) is maintained during fluctuations in blood pressure. We derive an index of autoregulation by measuring the rates of decrease (and recovery) of blood flow and blood pressure resulting from a sudden, induced change in systemic blood pressure (i.e., bilateral thigh cuff deflation). Second, we utilized pulsatile blood flow to estimate the critical closing pressure (CrCP) of cerebral microvasculature, i.e., the arterial blood pressure at which CBF approaches zero. Notably, CrCP can be an indicator of intracranial pressure and vasomotor tone. In both cases, our pilot experiments in healthy volunteers show that DCS measured rates of micro-vascular regulation and CrCP are in good agreement with comparable metrics derived with transcranial Doppler ultrasound.

![Diagram showing experimental setup and measurement protocol](image.png)

Figure 1 – (A) Experimental setup (B) Measurement protocol and representative results. CBF & ABP were be continuously monitored at 20Hz. Baseline measurements were used to compute Critical Closing Pressure, by fitting pulsatile CBF & ABP to a two-element Windkessel model. Cerebral autoregulation dynamics were averaged from three blood pressure manipulation trials. A rate of regulation (ROR) was estimated from the slope of the rate of change of cerebrovascular resistance post cuff deflation.