MICROVASCULAR CEREBRAL HEMODYNAMICS IN PEDIATRIC SICKLE CELL DISEASE WITH DIFFUSE CORRELATION SPECTROSCOPY

Erin M. Buckley of Emory University/Georgia Institute of Technology
Erin.buckley@emory.edu
Seung Yup Lee, Emory University
Eashani Sathialingam, Emory University/Georgia Institute of Technology
Kyle Cowdrick, Emory University/Georgia Institute of Technology
Kendall Williams, Emory University/Georgia Institute of Technology
Bharat Sanders, Emory University
Courtney E. McCracken, Emory University
Wilbur Lam, Emory University/Georgia Institute of Technology
Clinton H. Joiner, Emory University

Key Words: Diffuse correlation spectroscopy, near infrared spectroscopy, cerebral blood flow, sickle cell disease

Sickle cell disease is a genetic blood disorder that has profound effects on the brain. Chronic anemia combined with both macro- and micro-vascular perfusion abnormalities that arise from stenosis or occlusion of blood vessels, increased blood viscosity, adherence of red blood cells to the vascular endothelium, and impaired autoregulatory mechanisms in sickle cell disease patients all culminate in susceptibility to cerebral infarction. Indeed, the risk of stroke is 250 times higher in children with sickle cell disease than in the general population. Unfortunately, while transcranial Doppler ultrasound (TCD) has been widely clinically adopted to longitudinally monitor macrovascular perfusion in these patients, routine clinical screening of microvascular perfusion abnormalities is challenging with current modalities (e.g., positron emission tomography, magnetic resonance imaging) given their high-cost, requirement for sedation in children < 6y, and need for trained personnel. In this pilot study, we first assess the feasibility of a low-cost, noninvasive optical technique known as Diffuse Correlation Spectroscopy (DCS) to quantify an index of resting-state cortical cerebral blood flow in 11 children with SCD along with 11 sex- and age-matched healthy controls. As expected, blood flow index was significantly higher in sickle subjects compared to healthy controls ($p < 0.001$). Within sickle subjects, blood flow index was inversely proportional to resting-state arterial hemoglobin levels ($p = 0.012$), consistent with expected anemia-induced compensatory vasodilation that aims to maintain adequate oxygen delivery to the tissue. Further, in a subset of patients measured with transcranial Doppler ultrasound, DCS-measured blood flow was correlated with TCD-measured blood flow velocity in middle cerebral artery ($R_S = 0.68$), although the trend was not statistically significant ($p=0.11$). These results are consistent with those of several previous studies using traditional neuroimaging techniques to quantify cerebral blood flow, suggesting that DCS may be a promising low-cost tool for assessment of tissue-level cerebral blood flow in pediatric sickle cell disease. Finally, given that sickle cell disease is often associated with severe anemia, we next assessed the potentially confounding effects of hematocrit on the DCS-measured blood flow index using a microfluidic tissue-simulating phantom. For a fixed flow rate in the microfluidic channels, we show that blood flow index is inversely correlated with hematocrit, and we present a means to correct the measured blood flow index for hematocrit in anemic conditions.