Dynamic Vascular Assessment of Brain Circulation for Sports-Related Concussion

Meeting: European Society of Neurosonology and Cerebral Hemodynamics

Meeting Date: May 2004; Giessen, Germany

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Background: There are 300,000 sports-related concussions (SRC) in the USA, yearly. Most are mild and brief, but SRC can be severe and persistent, especially with recurrent injuries. There is no acute treatment. Return to play decisions (RTPD) are based on clinical symptoms, or on neuropsychological testing (NPT). Experimental evidence suggests a mismatch in brain metabolism and blood flow after concussion, with impaired vascular function or responsiveness, which may contribute to the injury, and be important for recovery as well as RTPD. Transcranial Doppler ultrasound (TCD) can study cerebral hemodynamics and vascular responsiveness, but in the presence of high flow velocity, it is hard to distinguish stenosis or spasm from hyperemia. Dynamic Vascular Assessment (DVA; New Health Sciences, Inc, Rockville, MD) is a new method for analysis of TCD results, providing additional insights into cerebrovascular performance and function. This pilot study reports the use of TCD with DVA in SRC.

Methods: The study protocol included TCD testing at rest and during breath holding, a brief neurological exam, and computerized NPT (ImPACT), at baseline and serially after SRC (24-48 h, 8-12 d, 4-6 wks) in athletes competing in 2002 and 2003 men's football and soccer and women's soccer, at Wake Forest University and Forsyth Country Day School. Among 215 athletes enrolled (173 at WFU, 140 football) there were 18 SRC in the study cohort, 10 with baselines, with another 9 outside athletes referred for study after SRC, for a total of 27 SRC.

Results: No focal neurological deficits were seen, and NPT results showed impairment initially that typically cleared by one week. Initial analysis of pooled data shows significant differences ($p<0.0001$) in the middle cerebral artery between baseline and all post-concussion time points for mean flow velocity, the Dynamic Flow Index, and the Dynamic Work Index, in a pattern suggesting reactive or breakthrough hyperemia, that persisted to >30 days after SRC. Additional analyses (paired data, breath holding) are pending.

Conclusions: This study confirms the feasibility of the methods, and demonstrates altered cerebral hemodynamics after SRC, with a persistent pattern of reactive or breakthrough hyperemia involving the capacitance vessels; decreasing impedance with proximal compensation, suggesting an earlier ischemic injury as might occur with vasospasm or edema after SRC. Significantly altered cerebral hemodynamics after SRC suggest a potential for acute treatment to correct or avoid ischemic injury, a possible role for TCD with DVA as a surrogate marker to evaluate the effect of treatments, and potential to assist with RTPD. Our study also highlights the need for acute evaluation in the minutes and hours after SRC, and even longer follow up.