

Dynamic Vascular Assessment of Brain Circulation for Sports-Related Concussion

Authors: Tegeler CH*, Kim JY*, Martin D*, Collins G**, Steelman D**, Westwood K***, Wyss R**, Pecina A**, Reynolds P*, Wake Forest University School of Medicine*, Wake Forest University**, and Forsyth Country Day School***, Winston-Salem, NC

Background: There are 300,000 sports-related concussions (SRC) yearly in the USA; most mild and brief, but may be severe or persistent, especially with recurrent SRC. There is no acute treatment. Return to play decisions (RTPD) are based on clinical symptoms, or neuropsychological testing (NPT). There is a mismatch in brain metabolism and blood flow after SRC, with impaired vascular function or responsiveness. This may add to the injury, or be important for recovery and RTPD. Transcranial Doppler ultrasound (TCD) can study cerebral hemodynamics and vascular responsiveness. Dynamic Vascular Assessment (DVA; New Health Sciences, Inc, Rockville, MD), a new method to analyze TCD data, gives additional insights into vascular performance and function.

Method: The protocol included TCD at rest and during breath holding, brief neurological exam, and computerized NPT (ImPACT), at baseline and after SRC (24-48 h, 8-12 d, 4-6 wks) for athletes in men's football and soccer and women's soccer, at Wake Forest University and Forsyth Country Day School. In 217 athletes enrolled (172 WFU, 141 football) there were 20 SRC in the study cohort, 10 with baselines, and another 6 SRC in other sports or from outside referrals; total 26 SRC.

Results: There were no focal neurological deficits. NPT showed impairment initially and typically cleared by 1 week. First analysis of pooled data shows significant differences in the MCA for baseline vs all post-SRC time points for the mean flow velocity, the Dynamic Flow Index, and the Dynamic Work Index (ANOVA $p < 0.0005$). The pattern suggests reactive or breakthrough hyperemia, and persisted to >30 days after SRC.

Conclusion: This pilot study confirms feasibility of the method, and shows altered 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. Altered cerebral hemodynamics after SRC suggest a potential for an acute treatment to correct or avoid ischemic injury, a possible role for TCD with DVA as a surrogate marker to assess the effect of treatments, and potential as an objective tool to assist with RTPD. Our study also highlights the need for acute evaluation after SRC, with even longer follow up.