Multi-sensor Optical and Ultrasound-based Assessment of Micro- and Segmental Flow Changes in Lower Extremity Following Controlled Physiologic Provocations

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PURPOSE: The ability of realtime evaluation of peripheral flow changes in lower extremities during manipulative procedures has potential applications in the area of better understanding the autonomic basis of procedures such as osteopathic manipulative treatments (OMT), and to monitor the effectiveness of physical manipulative treatments. A novel monitoring approach simultaneously measures segmental artery velocity (spectral Doppler ultrasound) and micro-vascular tissue blood volume [photo-pulse plethysmography (PPG)], enabling a better understanding of autonomic changes in the vascular system following physical provocation tests.

APPROACH: A Doppler ultrasound sensor (Vista AVS, Summit Doppler, CO) was applied to the dorsalis pedis artery of clinically asymptomatic subjects. This clinical device has a customized computer interface for continuous Doppler signal acquisition, and a custom-designed fixed angle probe holder. A PPG sensor (Biopac, CA) was attached on the subject's corresponding great toe. The ultrasound Doppler signal provides information related to the flow velocity in the segmental artery, whereas the PPG sensor signal is representative of the volumetric, microcirculatory status of the great toe. Eight clinically asymptomatic subjects were tested, whereby the dorsalis pedis Doppler signal was continuously recorded during controlled physiologic provocations namely, occlusion of the calf vessels using a blood pressure cuff, and passive raising of the lower legs. Baseline signals and data during vessel occlusion and passive limb elevation were acquired over 9 – 12 minutes. For additional 3 subjects, PPG signals were acquired from the great toe, in combination with ultrasound Doppler signals. Data were post analyzed to calculate the peak-peak, time average mean, and pulsatility characteristics.

RESULTS: A post occlusive hyperemic response is observed with increased peak-peak flow for ultrasound spectral Doppler as well as the PPG signal. When the lower extremities are elevated, enhanced negative flow is measured in ultrasound Doppler due to greater venous return and higher cardiac pre-load conditions. The PPG signal showed an increase in its peak-peak values potentially due to reduced local sympathetic activity.

DISCUSSION: A new longterm simultaneous recording and analysis technique for micro- and segmental vasculature for the lower extremity is developed. In clinically asymptomatic subjects (n = 8), the change in blood supply following physiologic provocations at both vascular levels is reflective of an autonomic response at the peripheral and central cardiac levels. This test capability is suitable for monitoring vascular changes following OMT.

REFERENCES: Eicke et al., Comparison of continuous wave Doppler ultrasound of the radial artery and laser Doppler flowmetry of the fingertips with sympathetic stimulation, J Neurol 251: 958–962 (2004)

DISCLOSURE: The present human subjects study was conducted under ATSU-IRB protocol approval.