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DIGITAL THERMAL MONITORING: NEW INDICATORS TO ASSESS VASCULAR HEALTH

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ABSTRACT:

Cardiovascular disease (CVD) is the world's leading cause of death; a majority of cases include occlusive disorders of the coronary arteries leading to coronary artery disease (CAD) or disorders of the cerebral arteries leading to stroke broadly classified as atherosclerosis. In order to diagnose CVD in its asymptomatic stages, both structural and functional evaluations of the endothelium exist. While structural assessments like coronary artery calcium (CAC) scores or carotid intima-media thickness (cIMT) are good markers of vascular health, functional evaluation of the endothelium in response to factors such as occlusion, cold, and stress has been found to be a better predictor of the health of the endothelium. Digital Thermal Monitoring (DTM) is a noninvasive functional evaluation technique that assesses vascular reactivity by measuring the recovery of fingertip temperature after 2–5 min. of brachial occlusion. On release of occlusion, the finger temperature responds to the overshoot in blood flow rate referred to as reactive hyperemia (RH), which has been shown to correlate with vascular health.

Numerical simulations of a finger were performed to establish the relationship between DTM and RH. The model finger consisted of essential components including bone, tissue, skin, major blood vessels (macrovasculature) and the microvasculature. The macrovasculature was represented by a pair of arteries and veins, while the microvasculature was represented by a porous medium. The time-dependent Navier–Stokes and energy equations were solved numerically to describe the temperature distribution inside and external to the finger. Simulation results were very similar to measured fingertip temperature profiles in terms of basic shape, temperature variations, and time delays at time scales associated with both heat conduction and blood perfusion.

Using this computational framework, adjusted measures of DTM accounting for the finger size, thermo-physical properties, external environment and initial vascular state were developed. The reactive response, thus obtained, has a well-defined peak (adjusted temperature reactivity, aTR) and is more representative of vascular reactivity in response to occlusion. The aTR measure can be further scaled and is shown to collapse to a single curve as a function of the flow overshoot index for a range of start temperatures (initial vascular state). The scaled aTR thus reduces the dependence on the initial vascular state and external environment leading to a more robust and reliable measure of vascular reactivity.

BIOGRAPHY:

Wasy Akhtar received his M.S in 2006 and Ph.D. in 2011 from the Department of Mechanical Engineering at the University of Houston. He currently works in the oil industry and is involved in the design of steel and composite risers for deep water applications. He is also evaluating current CFD capabilities to predict vessel motions under severe environmental loads. His research interests include computation of boiling flows on adaptive octree grids, non-invasive techniques to assess cardiovascular health and fracture mechanics. While a graduate student at the University of Houston, he received the Hugh Scott Cameron Award by the ASME South Texas Section (STS) in April 2010. This award is given every year to the most outstanding graduate student across five Texas universities for demonstrating excellence in academic research and leadership. The award recognized his significant contribution towards the development of Digital Thermal Monitoring (DTM), a non-invasive tool for cardiovascular risk assessment, published in the Journal of Biomechanical Engineering in 2010. His work on DTM has led to 3 journal articles, 4 conference papers and one book chapter in "Asymptomatic Atherosclerosis: Pathophysiology, Detection and Treatment". Today, he will be presenting on the computational framework used to develop new indicators of DTM and its significance as a screening tool for assessing cardiovascular health.