A THEORETICAL MODEL OF METABOLIC BLOOD FLOW REGULATION: ANALYZING THE ROLES OF RED BLOOD CELLS, CONDUCTED RESPONSES, AND CAPILLARY RECRUITMENT. J.C. Arciero[1], B.E. Carlson[2], and T.W. Secomb[1,3]; [1]Program in Applied Mathematics, University of Arizona, Tucson, AZ 85721 USA; [2]Department of Bioengineering, University of Washington, Seattle, WA, 98195 USA; [3]Department of Physiology, University of Arizona, Tucson, AZ, 85724 USA

In the presence of increased metabolic demand, red blood cells release ATP at a rate that depends on their oxyhemoglobin saturation level, triggering an upstream conducted response and arteriolar vasodilation. A theoretical model is used to predict oxygen saturation and ATP levels along a vascular pathway of seven representative segments, including two vasoactive arteriolar segments. In the model, blood flow is regulated by these arterioles whose diameters vary with conducted responses, wall tension, and wall shear stress. An expression for the conducted response signal is defined by integrating the ATP concentration along the vascular pathway, taking into account exponential decay of the signal in the upstream direction. This model predicts an increase in flow as oxygen demand increases from low to moderate levels but does not yield the high levels of perfusion seen at maximal exercise. The effects of capillary recruitment were examined by assuming a three-fold increase in perfused capillary density in response to increasing metabolic demand. Combining the effects of the conducted, myogenic, and shear-dependent responses with capillary recruitment can account for an increase in perfusion with increased oxygen demand that is consistent with experiments involving human knee extensor exercises. Supported by NIH Grant HL70657.