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(G) A Constrained Constructive Optimization Model of Branching Arteriolar Networks in Rat Skeletal Muscle

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At the organ and tissue level, the circulation relies on branching networks of microvessels to supply oxygen and other nutrients to all cells in support of metabolism, as well as remove metabolic waste, and derangement of the structure or function of these networks is directly linked to tissue dysfunction. Over a wide range of diameters, these networks are binary trees and display distinct geometric and hemodynamic properties. Although experiment-based reconstruction of these vascular structures has improved recently, there remains a strong motivation for developing theoretical models that match measured statistical properties of microvascular networks under healthy conditions and with elevated disease risk (e.g., diabetes) and can be used for computational studies of flow, transport, and regulation. These efforts have the ultimate objective of connecting specific vascular defects to observed modes of tissue dysfunction. In the present study, two-dimensional arteriolar networks in rat skeletal muscle are constructed based on the constrained constructive optimization (CCO) algorithm using published geometric and hemodynamic data obtained via intravital video-microscopy. Results obtained assuming blood is a single-phase Newtonian fluid demonstrate how network geometry, fractal dimension, and flow properties depend on the Murray's law exponent (g). In addition, using a two-phase (plasma and red blood cells, RBCs) flow model, we show the importance of microvascular blood rheology in determining network properties. Future work will focus on constructing three-dimensional networks, tissues other than skeletal muscle, and determining the effects of both domain shape and g.

Keyword-1

Computational modeling

Keyword-2

Perfusion distribution

Keyword-3

Microvascular networks

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