**Comparing Healthy and Diseased Vascular Networks to Better Understand Pathologies**

***Abstract***

***Introduction***

By recognizing the self-similarity (a property where at any magnification, a smaller piece of an object is similar to the object as a whole) in vascular systems, relationships can be recognized between vessel characteristics at different levels of the network's hierarchy. These relationships could be important for recognizing differences between the diseased state of a system versus the healthy state of a system. Observations have been shown to be important for drug delivery, tumor growth, and may be for stroke recovery.

The WBE model suggests that metabolic rate is a function of body mass with a scaling exponent of 3/4. It is useful in determining vessel radii and vessel lengths in a vascular network. The model rests on three core assumptions and a larger set of eight assumptions: 1) Vessels within the same level of hierarchy are equivalent, meaning they share the same radius, length, and flow rate. 2) The vascular system minimizes energy loss caused by impedance (blood wave reflections at vessel junctions) and dissipation (energy lost due to friction on vessel walls). 3) The vascular network is space filling, meaning the network must span the body to enable all cells to be locally fed by a capillary. By recognizing that total blood volume is proportional to the sum of the service volumes at each level of the vascular network, ratios between radii and length at different levels of the vascular network can be calculated. These assumptions lead to the conclusion that scaling exponents for radius and length at different hierarchies of a vascular network can be used to find information about an averaged network. By analyzing real data, we recognize that many of the assumptions made in the WBE model neglect some characteristics of real vascular systems, for example, loopy veins and asymmetry. Loopy veins are prevalent in the brain, where activity levels and oxygen demand are high. Asymmetry of vessels is shown in the coronary arteries, which must transition quickly to capillaries in order to supply blood to the heart. Four current methods, based on the assumptions of the WBE model, can be used to determine the scaling exponents for radius and length. Scaling exponents can be calculated using the conservation-based method, the ratio-based, the distribution-based method, and the regression-based method.

Prior methods of obtaining vascular data are inefficient and time consuming. By utilizing image processing, we are able to generate data about the radius and length of the vessels in a vascular system. This paper first attempts to validate the methods for vessel extraction from 3D vascular images. We compare data from two versions of software, Angicart, which already exists and has been tested, and a new version of software written in C++, which needs to be tested in regards to handling tree-like networks (vascular networks that lack loops). If we can validate that the new software works, we will use it to analyze loopy networks such as those seen in stroke recovery.

Using software to extract data on the structural properties of vessels from 3D vascular images, we can predict properties such as metabolic rate, growth rate, and drug delivery. By acknowledging the gaps in the original model, we can improve the assumptions of the framework and better understand real vascular networks. Using methods to calculate scaling exponents and comparing data from healthy systems to that of diseased systems, we recognize relationships that can lead to further knowledge on how to treat these conditions.

***Methods***

***Results***

***Discussion***