Contribution ID: **168** Type: **Oral Presentation**

Predicting blood flow and oxygenation in an image-based retinal vascular network

Wednesday, 11 July 2018 10:30 (30 minutes)

Impaired oxygen delivery and blood flow have been identified as significant factors that contribute to the loss of retinal ganglion cells in glaucoma patients. It is unknown, however, whether changes in blood flow to the retina are the cause or effect of retinal ganglion cell death, and a combined experimental and theoretical approach is needed to analyze the relationship between blood flow impairment and glaucoma. In this talk, recent data-driven theoretical models will be presented that predict how issues with blood flow regulation could lead to the impaired oxygenation seen in experimental glaucoma data. Then, an updated representation of the retinal vasculature based on confocal microscopy images will be introduced. These images reveal a complex and heterogeneous geometry of vessels that are distributed non-uniformly into multiple distinct retinal layers at varying depths. As a result, an updated model using a Green's function method is used to predict oxygen saturation in the retinal arteriolar tree, in addition to predicting blood flow in the entire vascular network. Finally, a framework will be introduced to incorporate time-dependent blood flow regulation into the model, so that vessels in the network can adjust diameters in response to changing conditions. The predictions from this mathematical model will be used to address the controversy of the cause-and-effect relationship between retinal ganglion cell death and impaired blood flow in glaucoma.

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Session Classification: Modelling feedback-mediated flow dynamics

Track Classification: Minisymposium: Modelling feedback-mediated flow dynamics