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THE EYE AS A WINDOW ON THE BODY: MATHEMATICAL CHALLENGES AND CLINICAL APPLICATIONS

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Abstract:

The eye is the only place in the human body where blood flow and systemic vascular features can be observed and measured easily and non-invasively down to the capillary level. Numerous clinical studies have shown correlations between alterations in retinal blood flow and ocular diseases (e.g. glaucoma, age-related macular degeneration, diabetic retinopathy), neurodegenerative disorders (e.g. Alzheimer's disease, Parkinson's disease) and other systemic pathologies (e.g. hypertension, diabetes). Thus, deciphering the mechanisms governing ocular blood flow could be the key to the use of eye examinations as a non-invasive approach to the diagnosis and continuous monitoring for many patients.

However, many factors influence ocular hemodynamics, including intraocular pressure (IOP), arterial blood pressure and blood flow autoregulation, and it is extremely challenging to single out their individual contributions during clinical and animal studies. In the recent years, we have been developing mathematical models to aid the interpretation of clinical data. In this talk, we will present models describing the blood flow in the macro- and micro-vasculature of the retina and optic nerve head, accounting for the IOP-induced deformation of the vessel walls. Results will show how the synergy between mathematical modeling and clinical data allowed to estimate the relative contribution of IOP, arterial blood pressure and blood flow autoregulation on tissue perfusion. The mathematical challenges embodied in the models will also be discussed, and they include fluid-structure interactions and multiple scales in space and time.