Niels-Henrik Holstein-Rathlou
Department of Biomedical Sciences, University of Copenhagen, Denmark
e-mail: nhhr@sund.ku.dk
Olga Sosnovtseva
Department of Biomedical Sciences, University of Copenhagen, Denmark
e-mail: olga@sund.ku.dk
Donald J. Marsh
Brown University, Providence, RI, USA
e-mail: marsh@ash.biomed.brown.edu

Synchronization of nephrons in vascular networks

Tubuloglomerular feedback (TGF) has an important role in autoregulation of renal blood flow and glomerular filtration rate (GFR). Because of the characteristics of signal transmission in the feedback loop, the TGF undergoes self sustained oscillations in single nephron blood flow, GFR and tubular pressure and flow. Nephrons interact by exchanging electrical signals conducted electrotonically through cells of the vascular wall, leading to synchronization of the TGF mediated oscillations. To study the extent of synchronization we have used laser speckle contrast imaging to measure the blood flow dynamics of $50 - 100$ nephrons simultaneously on the renal surface of anesthetized rats. Synchronized TGF oscillations were detected in pairs or triplets of nephrons. The amplitude and the frequency of the oscillations changed with time, as did the patterns of synchronization. Synchronization may take place among nephrons not immediately adjacent on the surface of the kidney. Nephrons are organized in a vascular network, and the interaction between them takes place across the network. To investigate the significance of the network structure, we modeled two alternative network configurations: a linear serial network, and a branching fractal structure. Although synchronization among nephrons was observed in both configurations, the tendency was for in phase synchronization among nephrons in the linear, serial network; whereas more complex in- and out of phase patterns of synchronization was observed in the branching model of the vascular network.