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Synchronization of tubular pressure oscillations by vascular and hemodynamic coupling in interacting nephrons.

The kidney plays an essential role in regulating the blood pressure and a number of its functions operate at the functional unit of the kidney, the nephron. To understand the impacts of internephron coupling on the overall nephrons' dynamics, we develop a mathematical model of a tubuloglomerular feedback (TGF) system, a negative feedback mechanism for nephron's fluid capacity. Specifically, each model nephron represents a rigid thick ascending limb only and is assumed to interact with nearby nephrons through vascular and hemodynamic coupling along the pre-glomerular vasculature. We conduct a bifurcation analysis by deriving a characteristic equation obtained via a linearization of the model equations. To better understand the impacts of parameter variability on TGF-mediated dynamics, we investigated five cases with two coupled nephrons when i) vascular coupling is absent, ii) hemodynamic coupling is absent, iii) vascular and hemodynamic coupling strengths are identical, iv) vascular coupling is stronger, and v) hemodynamic coupling is stronger. Our model results show that the coupled-TGF system with two coupling effects can produce in-phase and anti-phase (out-of-phase) synchronization of tubular pressure oscillations in two nephrons, as has been reported in experimental studies. (Received September 20, 2015)