A fully coupled fluid-structure-muscle-electrophysiology model in heart development

Nicholas A. Battista[1,2], Laura A. Miller[1,2]
[1] Dept. of Mathematics, University of North Carolina at Chapel Hill
nickabattista@gmail.com
[2] Dept. of Biology, University of North Carolina at Chapel Hill
lam9@unc.edu

Fluid-structure interaction, heart development, electrophysiology

The vertebrate heart begins to pump when its morphology is nothing more than a valveless tube, composed of an outer layer of myocardial cells surrounding an inner layer of endocardial cells. It has been proposed that the purpose of the embyronic heartbeat is to aid in the growth and shaping of the heart itself in organogenesis, rather than the delivery of oxygen and nutrients [1]. These heart tubes have been described as peristaltic and impedance pumps. Impedance pumping assumes a single actuation point of contraction, while traditional peristalsis assumes a traveling wave of actuation. In addition to differences in flow, this inherently implies differences in the conduction system. It is possible to transition from one pumping mechanism to the other with a change in the diffusivity of the action potential. Using an open source implementation of the immersed boundary method, *IB2D* [2], we developed a fully coupled fluid-structure-muscle-electrophysiology model of the embryonic heart. We find that differences in the resulting pumping behavior, greatly affects the advection and diffusion of a chemical gradient within the heart tube. These chemical gradients, e.g., morphogens, could serve as an essential epigenetic signal required for proper cardiogenesis [3].

References

[1] W.W. Burggren, *What is the purpose of the embryonic heart beat? Or how facts can ultimately prevail over physiological dogma*, Physiology and Biochemical Zoology **77** 333-345, 2004.

[2] N.A. Battista, W.C. Strickland, L.A. Miller, *IB2d: a Python and MATLAB implementation of the immersed boundary method*, Bioinspiration & Biomimetics, *in press*

[3] J.L. Christian, *Morphogen gradients in development: from form to function*, Wiley Interdiscip. Rev. Dev. Biol. **1(1)** 3-15, 2012