frontiers in Physiology

EDITORIAL
published: 17 March 2022
doi: 10.3389/fphys.2022.865905

Editorial: Vascular Disease Multi-Scale Multi-Physics Modeling and Experimental Data

Sanjay R. Kharche[1,2,3]*, *Halina Dobrzynski*[2,4] *and Daniel Goldman*[1]

[1] Department of Medical Biophysics, Western University, London, ON, Canada, [2] Division of Cardiovascular Sciences, University of Manchester, Manchester, United Kingdom, [3] Kidney Clinical Research Unit, Lawson Health Research Institute, London, ON, Canada, [4] Department of Anatomy, Jagiellonian University Medical College, Kraków, Poland

Keywords: large data, vascular disease, multi-physics modeling, multi-scale computer modeling, collaboration

Editorial on the Research Topic

Vascular Disease Multi-Scale Multi-Physics Modeling and Experimental Data

MODERN EXPERIMENTAL METHODS NECESSITATE DATA INTEGRATION AND INTERPRETATION

Model experimental research generates large data. Technology now permits multi-scale investigations from sub-molecular to whole specimens (Evans et al., 2021). The Dobrzynski group use a combination of experimental-imaging methods to uncover crucial relationships between cardiac structure and function (Dobrzynski and Boyett, 2006; Logantha et al., 2016) to advance our understanding of whole heart pathophysiology.

In this Research Topic, Yin et al. succinctly show how integrating multi-scale experimental data scaffolded by mechanistic computational modeling has led them to a novel strategy wherein augmenting the number of smooth muscle cells in recovering skeletal muscle capillaries may treat peripheral arterial disease. The method and techniques work by Liu et al. provides a stable and minimally invasive rabbit model of cerebral stenosis that permits investigation of underlying whole body hemodynamic processes in a physiologically informative manner.

We believe that data driven multi-scale computational modeling is a robust approach to integrate experimental knowledge and gain insights into key pathophysiological processes.

MULTI-SCALE COMPUTATIONAL MODELING INTEGRATES EXPERIMENTAL KNOWLEDGE

Computational modeling provides a quantitative paradigm to assess whether individual experimental findings "fit into a whole." The Goldman group combine microcirculation and organism level measurements to predict oxygen transport in skeletal muscle [see e.g., Farid et al. (2017)]. The Kharche laboratory uses experimental-clinical data to test otherwise intractable hypothesis such as cardiac sino-atrial node exit pathways and presence of peripheral arterial disease (Kharche et al., 2017, 2018) to further clarify existing scientific evidence.

In this Research Topic, Naber et al. have deployed computational fluid dynamics (CFD) and data analysis to reduce the quantitative uncertainty in calculating vessel transit time, accurate measurement of which may improve brain surgery outcomes. The work by Ai et al. computes coronary microvascular resistance using a combination of non-invasive angiography imaging and CFD modeling leveraged by their prior findings, an approach that may alleviate the use of risk

OPEN ACCESS

Edited and reviewed by:
Raimond L. Winslow, Johns Hopkins University, United States

***Correspondence:**
Sanjay R. Kharche
Sanjay.Kharche@lhsc.on.ca

Specialty section:
This article was submitted to Computational Physiology and Medicine, a section of the journal Frontiers in Physiology

Received: *30 January 2022*
Accepted: *21 February 2022*
Published: *17 March 2022*

Citation:
Kharche SR, Dobrzynski H and Goldman D (2022) Editorial: Vascular Disease Multi-Scale Multi-Physics Modeling and Experimental Data. Front. Physiol. 13:865905. doi: 10.3389/fphys.2022.865905

augmenting invasive wires. Hashemi et al. used CFD to compute a spectrum of hemodynamic parameters (e.g., wall shear stress, residence time) that allows stratification of the severity of atherosclerosis plaque driven stenosis, which may provide insights into smooth muscle cell and sub-cellular pathophysiological processes. The Tamis and Drapaca vascular tone model showed that an increased vessel wall stiffness is simultaneous to unavailability of important messengers such as nitrous-oxide, a description that can easily become incorporated into more detailed simulations upon suitable parameter identification. The multi-scale nephron model presented by Swapnasrita et al. strongly suggests that male and female kidneys respond differentially to diseases (diabetes) and pharmacological treatments (SGLT2 inhibition) due to the differential expression of sex specific transporters, a finding that will streamline future animal experiments and clinical trials. The machine learning work presented in this Research Topic (Bizjak et al.) shows the relevance of deep data inquiry (i.e., aneurysm sphericity, size, and volume) to enable reliable cerebral aneurysm rupture risk prediction, a modeling approach that is expected to find extensive application in the wider large data ecosystem.

DEEPER COLLABORATION AS AN UNMET NEED

It can be appreciated that experimentalists, modelers, and clinicians are traditionally considered to be end users of each other's knowledge. We believe that an important factor in translation is a deeper inter-field engagement (Yoda, 2016) which may lead to methods refinement, accelerated research outcomes, as well as synergize knowledge exploitation to improve human and animal quality of life.

AUTHOR CONTRIBUTIONS

SK wrote the editorial, which was revised and approved by DG and HD. All authors contributed to the article and approved the submitted version.

FUNDING

This work was supported by Canada's Canarie Inc (RS3-111).

ACKNOWLEDGMENTS

The authors thank the Kidney Clinical Research Unit, Lawson Health Research Institute, Canada for supporting SK and his team. The authors also thank Western University Canada and Manchester University UK for supporting SK, DG, and HD. Finally authors thank Frontier's journal for providing us the opportunity to organize this Research Topic.

REFERENCES

Dobrzynski, H., and Boyett, M. R. (2006). What do we learn from double Cx40/Cx45-deficient mice about cardiac morphogenetic defects and conduction abnormalities? *J. Mol. Cell Cardiol.* 41, 774–777. doi: 10.1016/j.yjmcc.2006.08.014

Evans, P., Wojta, J., Hoefer, I. E., Waltenberger, J., Guzik, T., Badimon, L., et al. (2021). The year in basic vascular biology research: from mechanoreceptors and neutrophil extracellular traps to smartphone data and omics. *Cardiovasc. Res.* 117, 1814–1822. doi: 10.1093/cvr/cvab105

Farid, Z., Saleem, A. H., Al-Khazraji, B. K., Jackson, D. N., and Goldman, D. (2017). Estimating blood flow in skeletal muscle arteriolar trees reconstructed from in vivo data using the Fry approach. *Microcirculation* 24, e12378–n/a. doi: 10.1111/micc.12378

Kharche, S. R., So, A., Salerno, F., Lee, T. Y., Ellis, C., Goldman, D., et al. (2018). Computational assessment of blood flow heterogeneity in peritoneal dialysis patients' cardiac ventricles. *Front. Physiol.* 9:511. doi: 10.3389/fphys.2018.00511

Kharche, S. R., Vigmond, E., Efimov, I. R., and Dobrzynski, H. (2017). Computational assessment of the functional role of sinoatrial node exit pathways in the human heart. *PLoS One* 12:e0183727. doi: 10.1371/journal.pone.0183727

Logantha, S. J., Stokke, M. K., Atkinson, A. J., Kharche, S. R., Parveen, S., Saeed, Y., et al. (2016). Ca(2+)-clock-dependent pacemaking in the sinus node is impaired in mice with a cardiac specific reduction in SERCA2 abundance. *Front. Physiol.* 7:197. doi: 10.3389/fphys.2016.00197

Yoda, T. (2016). The effect of collaborative relationship between medical doctors and engineers on the productivity of developing medical devices. *R&D Manage.* 46, 193–206. doi: 10.1111/radm.12131

Conflict of Interest: The authors declare that the research was conducted in the absence of any commercial or financial relationships that could be construed as a potential conflict of interest.