14th World Congress in Computational Mechanics (WCCM)
ECCOMAS Congress 2020
11-15 January, 2021, Paris, France

APPLICATION OF THE SMEARED CONCEPT IN PATIENT-SPECIFIC HEART ELECTROPHYSIOLOGY MODELS

Miljan Milosevic[1,2], Bogdan Milicevic[1], Vladimir Geroski[1], Vladimir Simic[1] and Milos Kojic[1,3,4]

[1] Bioengineering Research and Development Center BioIRC Kragujevac, Prvoslava Stojanovica 6, 34000 Kragujevac, Serbia, miljan.m@kg.ac.rs, dd11eeaann@gmail.com, vlada.geroski@gmail.com, vladimir.simic.991@gmail.com

[2] Belgrade Metropolitan University, Tadeusa Koscuska 63, 11000 Belgrade, Serbia.

[3] Houston Methodist Research Institute, The Department of Nanomedicine, 6670 Bertner Ave., R7 117, Houston, TX 77030, USA, mkojic42@gmail.com

[4] Serbian Academy of Sciences and Arts, Knez Mihailova 35, 11000 Belgrade, Serbia

Key Words: *Composite smeared finite element, Electrophysiology, Ionic transport, Conductivity tensor, Heart model*

Recently developed composite smeared finite element (CSFE) offers efficient solutions for electrophysiology and ionic transport problems [1,2]. Using of CSFE enables transformation of discrete transport, approximated by 1D finite elements within nervous system, into a continuum format represented by formulation of conduction tensor.

Electric signals are traveling to the heart through the Purkinje fiber network located in thin layer of heart wall called the subendocardium. In order to appropriately take into account this Purkinje network in our CSFE model, additional uniform 3D layer of FE element is generated and added to 3D heart domain. Transport characteristic of uniform 3D domain, in form of conduction tensor, are calculated based on fractal-based [3] or manually generated Purkinje 1D mesh projected on 3D real model of human heart. Additional parameters describing this uniform 3D domain are thickness of Purkinje network layer and volume fraction of Purkinje fibers.

Accuracy of presented methodology and procedure with additional uniform layer is tested on several simple 2D and 3D examples of heart tissue with Purkinje fiber's network. Applicability of the model is shown on real 3D heart model with prescribed electrical signals, where parametric and real heart FE meshes used in simulations are automatically generated using our in-house modelling software, and by varying geometrical parameters of the model. Using this methodology we can accurately predict transport of electrical signals for the virtual repository of the patients created by our modelling software.

Acknowledgement: This project has received funding from the European Union's Horizon 2020 research and innovation programme under grant agreement No 777204 (SILICOFCM project – www.silicofcm.eu). This article reflects only the author's view. The Commission is not responsible for any use that may be made of the information it contains.

REFERENCES

[1] M. Kojic, et al, Smeared multiscale finite element model for electrophysiology and ionic transport in biological tissue, Computers in Biology and Medicine, Volume 108, pp. 288-304, 2019.

[2] M. Kojic, et. al, Smeared multiscale finite element models for mass transport and electrophysiology coupled to muscle mechanics, Frontiers in Bioengineering and Biotechnology, Vol 7, 2019, DOI: 10.3389/fbioe.2019.00381, ISSN: 2296-4185.
[3] F. Costabal, D.E.Hurtado, E. Kuhl, Generating Purkinje networks in the human heart, Journal of Biomechanics 49(2016)2455–2465.