The 8th European Congress on Computational Methods in Applied Sciences and Engineering
ECCOMAS Congress 2022
5-9 June 2022, Oslo, Norway

Mathematical and numerical modeling of cardiac electromechanics in scar-related ventricular tachycardia

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Keywords: *Cardiac Electromechanics, Ventricular Tachycardia, Mechano-electric Feedbacks, Mathematical modeling, Numerical Methods*

The coupling between the electrical activity of the heart and its mechanical contraction plays a fundamental role in the physiological processes underlying the cardiac function. For this reason, numerical simulations of ventricular electromechanics are gaining momentum in cardiovascular research. Given the importance of analyzing and better addressing pathological conditions using anatomically accurate and biophysically detailed personalized computational models that embrace electrophysiology, mechanics and hemodynamics, we develop a novel electromechanical model for human ventricles affected by ischemic cardiomyopathy. This is made possible thanks to the introduction of a spatially heterogeneous coefficient that accounts for the presence of scars, grey zones and non-remodeled regions of the myocardium. We couple this 3D electromechanical model to a 0D closed-loop circulation model by an approach that is energy preserving. Our mathematical framework keeps into account the effects of mechano-electric feedbacks, which model how mechanical stimuli are transduced into electrical signals. Moreover, it permits to classify the hemodynamic nature of ventricular tachycardia, which has significant clinical implications. Our electromechanical model can be used in patient-specific cases to perform comprehensive studies of any type of arrhythmia, ranging from bradycardia to fibrillation.
This research has been funded by Italian Ministry of University and Research (MIUR) within the PRIN (Research projects of relevant national interest 2017 “Modeling the heart across the scales: from cardiac cells to the whole organ” Grant Registration number 2017AXL54F).

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