A Framework for Personalized Cardiovascular Models in Hypertrophic Cardiomyopathy

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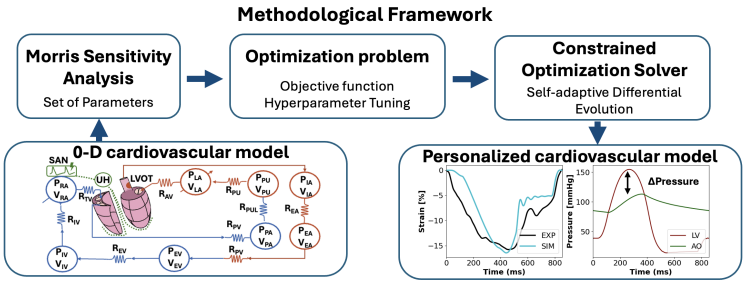
Context: Hypertrophic cardiomyopathy (HCM) is a genetic cardiovascular disease with a complex and heterogeneous phenotype. Myocardial strain, assessed by speckle-tracking echocardiography (STE), is a reliable marker of LV function but remains difficult to interpret. This work aimed to present a framework for building personalized HCM cardiovascular models for better understanding the underlying mechanisms of myocardial deformation.

Methods: The retrospective database included 50 HCM patients, enrolled in Rennes University Hospital, who underwent 2D-STE. The proposed cardiovascular model included multi-segment ventricles, atrias, systemic and pulmonary circulations. The methodological framework included: 1) a Morris sensitivity analysis to establish the set of parameters that should be identified, 2) the definition of a mono-objective function, between clinical and simulated longitudinal strains and LV outflow track (LVOT) pressure gradients, and a grid search tuning for an hyperparameter, 3) a nested optimization algorithm, combining self-adaptive constraints handling and differential evolution, that was ran with 100 individuals and for 150 generations.



Results: A set of 85 mechanistic and hemodynamic parameters was used to personalize cardiovascular models. The mean Root Mean Square strain error was 4.0±0.6%. The mean LVOT pressure gradient absolute error was 2.8±4.1mmHg. This work paves the way towards the proposition of HCM digital twins to improve risk stratification.