

Model-based analysis of myocardial strains in obstructive and non-obstructive hypertrophic cardiomyopathy

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Context: Hypertrophic cardiomyopathy (HCM) is a genetic cardiovascular disease associated with increased left ventricular (LV) wall thickness, myocardial stiffness and impaired relaxation. HCM patients can present an obstruction of the LV outflow tract (LVOT) that could be associated with an increased risk of sudden cardiac death. Computational modelling could help to improve individual stratification of HCM through the integration of physiological modeling. The objective is to propose preliminary results of an integrated cardiovascular model, including LVOT, to reproduce strain curves in obstructive and non-obstructive HCM patients.

Methods: The retrospective database includes 96 patients, enrolled in Rennes University Hospital, who underwent a 2D-speckle-tracking transthoracic echocardiography. K-means clustering was applied on a set of 12 clinical and echocardiographic features per patient. Virtual patients were defined, from a computational model, for patients associated with the centroid of each cluster, by adjusting manually model parameters to reproduce longitudinal strain curves. The proposed model was defined by coupling a representation of LVOT to an integrated model of the cardiovascular system that includes: i) systemic and pulmonary circulations and ii) multi-segment cardiac cavities.

Results: Two clusters were identified: 47 patients (64% obstructive) in cluster 1 (C1) and 49 patients (24% obstructive) in cluster 2 (C2). Virtual patients, associated with the centroid patient of each cluster, were defined to reproduce strain curves and LVOT pressure gradient. A close match was observed between simulated and clinical strains with mean RMSE equal to $3.85\% \pm 1.25$ for C1 centroid (obstructive patient) and $3.42\% \pm 1.28$ for C2 centroid (non-obstructive patient).

Conclusion: A novel integrated model of the cardiovascular system was proposed to include LVOT obstruction in HCM patients. The model was able to reproduce clinical longitudinal strains and LVOT pressure gradient. Future works will be dedicated to patient-specific identification of model parameters and analysis of a larger database.

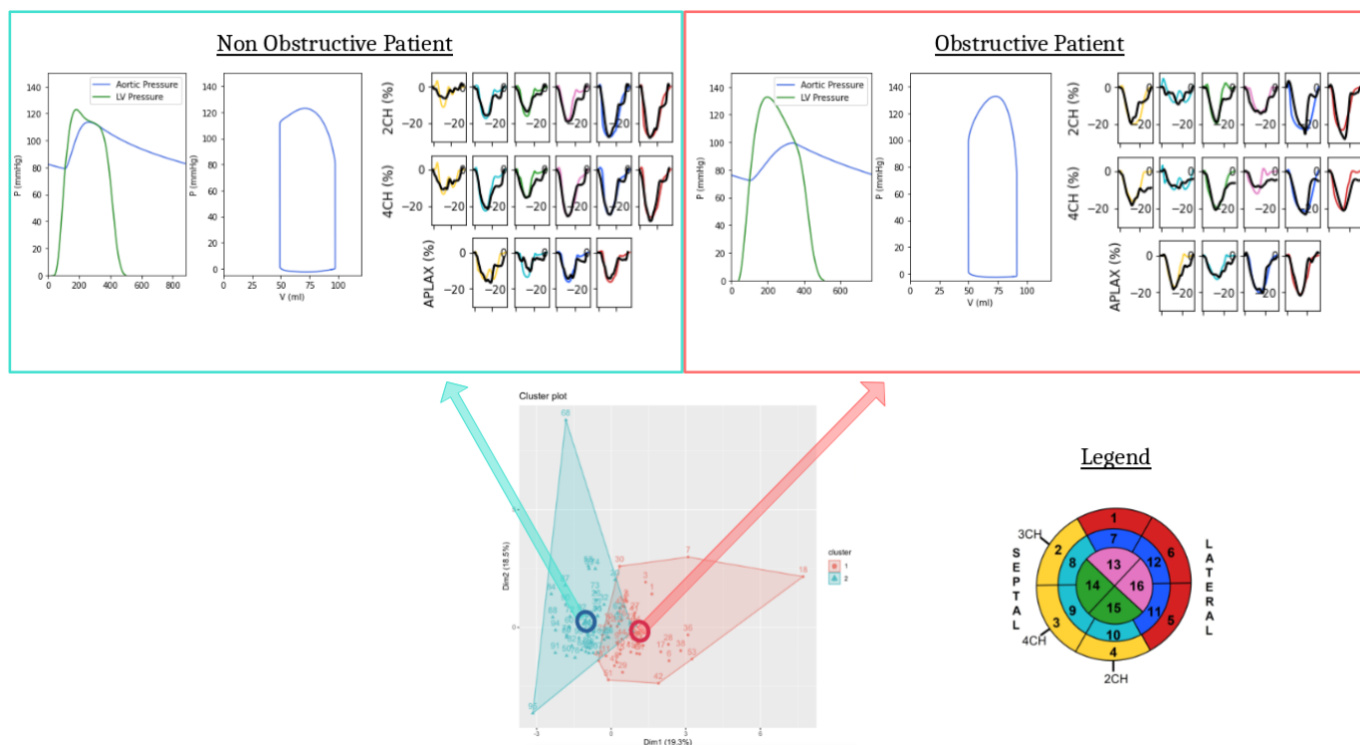


Figure 1. Bottom: Kmeans clusters: non-obstructive (turquoise) and obstructive (salmon) patients and its centroids (circle). **Upper: left:** Patient-specific simulations results for both non-obstructive and obstructive HCM patients; aortic pressure (blue) and left ventricular pressure (green) showing the LVOT gradient; **center:** Pressure-volume loop to compare the left ventricular ejection fraction; **right:** Experimental (black) and simulated (colored) strain curves corresponding to the 16 LV segments.