

Comparisons of Patient-specific Active and Passive Models for Left Ventricle in Hypertrophic Obstructive Cardiomyopathy

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Abstract: Hypertrophic cardiomyopathy (HCM) occurs in about 1 of every 500 adults in the general population. It has been reported that left ventricular outflow tract obstruction (LVOTO) is observed in 70% patients with HCM. Systolic anterior motion (SAM) of the mitral valve (MV) is the dominant cause of dynamic outflow tract obstruction in most patients with hypertrophic obstructive cardiomyopathy (HOCM). Currently, the hemodynamic mechanisms of SAM remain unclear. In this study, we developed 12 active and corresponding passive models based on 6 patients' pre- and post-operative ECG-gated cardiac CT images of patients' LV at the pre-SAM time point (5% RR interval). The passive model treated the left ventricle muscle as passive material. The left ventricle was inflated/deflated by specific pressure conditions on inlet (mitral valve) and outlet (aortic valve) in the cardiac cycle. In the active model, the active contraction of LV from the end of the isovolumic systole to the pre-SAM time point was implemented by specifying the pressure conditions at the outlet and outer boundary of LV (epicardium). The simulation results between passive and active models were compared by paired-t test. The maximum wall stress obtained from passive models were found to be 40.7% higher than that from active models, while the maximum strain value in passive models were only 3.9% higher than that from passive models. The differences in fluid results between active and passive models were not significant. It was found both in active models and passive models that the pressure difference and shear stress on the mitral valve leaflet were significantly decreased after successful surgery while remaining high after failed surgery. Our results indicate that the passive model may be used as a good approximation to active models to perform mechanical analysis for left ventricle with clinical implementation potential. Prospective and large-scale studies are needed to further validate our findings.

Keywords: Passive model; active model; left ventricle; hypertrophic obstructive cardiomyopathy; systolic anterior motion

Acknowledgement: This research was supported in part by the Natural Science Foundation of Fujian Province of China (Grant No. 2017J01009) and the Fundamental Research Funds for the Central Universities (Grant No. 20720180004).