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Multi-Modality Image-Based Modeling Approach for Cardiovascular Disease: Simulation, Assessment, Prediction, and Virtual Surgery

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Medical imaging and image-based modeling have made considerable progress in recent years in cardiovascular research, such as identifying atherosclerotic plaque morphological and mechanical risk factors which may be used in developing improved patient screening strategies, and performing virtual heart surgery seeking optimal surgical procedures for best post-surgical outcome. We will report recent progress in using multi-modality image-based models to predict vulnerable plaque progression and vulnerability change. In particular, we will report our recent results using IVUS+OCT data to obtain more accurate stress/strain calculations. Inflammation and cap erosion will affect cap material properties. If OCT image could provide inflammation and erosion information, cap stress/strain calculation can be further improved. Preliminary results using molecular imaging will be presented.

Patient-specific ventricle models were constructed to perform virtual surgery for patients with repaired tetralogy of Fallot (TOF) to predict post-surgery outcome, and to seek parameters which could be used to identify patients who could benefit more from pulmonary valve replacement surgery. Cardiac magnetic resonance (CMR) data were obtained from 16 TOF patients (8 male, median age, 42.75) and 6 healthy group (HG) volunteers (1 male, median age, 20.1). CMR-based patient-specific computational RV/LV models were constructed to obtain RV wall thickness (WT), volumes, curvature, and mechanical stress and strain for comparative analysis. It was found that mechanical stress could be a good predictor for surgical outcome.

Keywords: Cardiovascular disease, ventricle model, vulnerable plaque.

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