The Influence of Left Atrial Wall Thickness and Curvature on Wall Strain in Patient-Specific Atrium Models

Tiffany MG Baptiste*, Angela Lee, Daniel B Ennis, Ulrike Haberland, Ronak Rajani, Aldo Rinaldi, Steven A Niederer

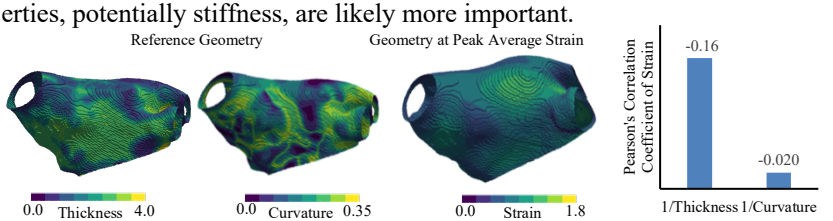
Department of Biomedical Engineering, King's College London
London, UK

Atrial fibrosis is a driver for the onset and maintenance of atrial fibrillation, a common arrhythmia which increases the risk of stroke and heart failure. In the left atrium (LA), time-varying strain is measured as an important biomechanical signal for fibrosis. It is expected that LA strain is influenced by LA anatomy, which is highly varied in terms of wall thickness and curvature. However, the extent to which atrial strain is determined by wall thickness and curvature remains unknown. This study aimed to investigate the relative contribution of wall thickness and curvature to local atrial strain using 10 patient-specific finite element LA models.

LA models were deformed from a reference configuration at end-diastole to simulate motion using feature tracking in retrospective gated cardiac computed tomography, which captured images of LA motion over the cardiac cycle. Local atrial area strain was quantified as the percentage change in area of each element of the endocardial surface relative to the reference geometry. Atrial wall thickness and curvature were calculated from the models at their reference configuration.

The average wall thickness and curvature across 10 models was 1.8±0.42 mm and 0.18±0.078 mm^{-1} respectively. Pearson's correlation coefficients of strain with LA wall thickness and curvature were calculated at peak average atrial strain in the cardiac cycle for each heart. The average correlation of strain with the inverse of wall thickness and curvature was -0.16±0.073 and -0.020±0.10 respectively. The correlations between wall thickness, curvature and the first four principal components of strain were also considered but showed no greater dependence of strain on wall thickness or curvature.

Wall thickness plays a greater role in determining atrial strain than curvature. However, neither appear to strongly influence strain. LA strain can unlikely be estimated from LA anatomy alone; other myocardial material properties, potentially stiffness, are likely more important.



Correlation of atrial area strain with wall thickness and curvature, with LA maps for 1 patient