An Image-based Approach for 3D Left Atrium Functional Measurements

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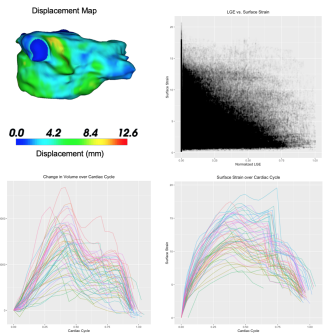
Introduction: There is a growing interest in accurate assessment of function of the left atrium (LA) in patients with atrial fibrillation (AF). Existing methods of LA function measurements only quantify a limited subset of the functional parameters from a single or biplane CINE MRI scan through the LA. In this study, we propose an image-based method for comprehensive evaluating the function of the entire LA in 3D.

Methods: 4D LA images were reconstructed from a series of CINE image stack covering whole LA with small or no gap between thin slices. Individual 3D volumes were extracted for each timepoint of the cardiac cycle. Manual segmentation from a high-resolution Magnetic Resonance Angiography (MRA) was registered to the closest time point. Deformable registrations were performed between each consecutive timepoint. A surface mesh was constructed from the MRA segmentation and warped through each timepoint registration to establish a high-density surface correspondence for each time point. Volume, LA ejection fraction (LAEF), 3D Euclidean per-vertex displacement, and surface strain were computed for each vertex at each timepoint. These 3D maps were then registered to Late Gadolinium Enhancement (LGE) volumes to correlate functional measurements with fibrotic tissue characterization.

Results: 3D strain and displacement maps were generated for each timepoint for each of 64 patient scans. Volume and strain curves were computed for each scan, and LAEF was calculated to be 27.5% $\pm$ 10.2%. Peak global surface strain, the 3D analog of longitudinal strain, was calculated to be 12.4% $\pm$ 3%. A correlation coefficient of -0.11 was calculated between LGE and strain, indicating that fibrotic tissue correlates with reduced elasticity.



Conclusion: A novel method for fusing and evaluating structural and functional 3D MRI through time using only a single segmentation has been described. A fully 3D assessment may offer significant advantages over traditional 2D approaches.