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Three-dimensional cardiac electromechanical activation mapping with in silico validation

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Abstract:
Background: Electromechanical wave imaging (EWI) is an ultrasound-based methodology that can map the electromechanical activation of the heart at high temporal resolution. Previous reports have shown strong correlation between EWI-based and electrical activation times. However, EWI has been performed only with 2D echocardiography, which cannot map the full cardiac volume.
Objective: Our objective is to implement 3D EWI for noninvasive electromechanical activation mapping of the heart and to evaluate its performance by comparing with computational electromechanical heart models.
Methods: A realistic 2D cardiac ultrasound array was simulated on an ultrasound imaging simulation platform (Field II). The “ground truth” benchmark of this study was the ventricular geometry and displacement obtained from a computational electromechanical model based on real human heart anatomy. Ultrasound images were acquired and processed to estimate inter-volume axial displacements and strains as well as electromechanical activation times.

Estimated axial displacements, strains and activation times from ultrasound simulations were compared against the benchmark.
Results: Estimated and true axial displacements were found to be strongly correlated (R2=0.99) in both the right and left ventricles. Good agreement was found between estimated electromechanical activation times and true electrical activation times.
Conclusions: This study indicates that noninvasive 3D electromechanical mapping of the heart is feasible during a single heartbeat. Experimental implementation of 3D EWI is currently under investigation and could improve efficiency of cardiac arrhythmia characterization.

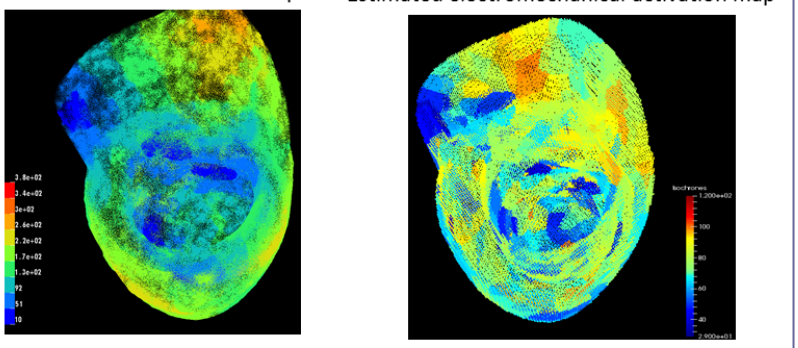

Figure 1: Comparison between true electrical activation times from finite element simulation of sinus rhythm and estimated electromechanical activation times from ultrasound simulation.

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Author Disclosure Information:

J. Grondin: None. **D. Wang:** None. **N.A. Trayanova:** None. **E.E. Konofagou:** None.
Category (Complete): 06 Computer Modeling/Simulation
Keywords (Complete): Echocardiography, transthoracic ; Myocardial contraction ; Activation mapping
Additional Information (Complete):
Presentation Preference: Oral or Poster
I am interested in submitting an abstract for one of the Late-Breaking Trials sessions.
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***Learning Objective:** : discover a new method for noninvasive 3D cardiac activation mapping

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