Submission ID: 223
Subject Classification: Clinical
Presentation Preference: Oral
Student Paper: Yes **Participate in the Student Paper Competition:** Yes
Invited Speaker: No
Keywords: Electromechanical Wave Imaging, 3D rendering, Cardiac Resynchronization Therapy , Heart failure

3D rendering of Electromechanical Wave Imaging for the characterization and optimization of biventricular pacing conditions in Heart Failure patients undergoing Cardiac Resynchronization Therapy

Lea Melki[1], Ethan Bunting[1], Daniel Wang[2], Pierre Nauleau[1], Elisa Konofagou[1,3]

[1]Biomedical Engineering, Columbia University, New York, NY, USA, [2]Medicine - Division of Cardiology, Columbia University, New York, NY, USA, [3]Radiology, Columbia University, New York, NY, USA

Background, Motivation and Objective

Assessing the response of heart failure (HF) patients to Cardiac Resynchronization Therapy (CRT) currently relies on the ECG and left ventricular (LV) ejection fraction. Electromechanical Wave Imaging (EWI) is a high frame-rate (2000 Hz) ultrasound-based technique capable of non-invasively mapping the electromechanical activation in all four cardiac chambers in vivo. In this study, we aim to show the capability of EWI in identifying different pacing conditions in patients with CRT and to characterize the resulting activation pattern directly following biventricular (BiV) device placement.

Statement of Contribution/Methods

A total of nine HF patients, each in three different pacing conditions (RV only, LV only and BiV), were imaged following their ICD implantation in four transthoracic standard echocardiographic apical views (4-, 2-, 3- and 3.5-chamber). Electromechanical strains and activation maps were computed in each view with EWI processing. Axial displacements were estimated using 1D RF cross-correlation, and strains were derived with a 5 mm least squares kernel. Activation times were defined by the sharp transition from positive to negative values on the incremental strain curves. LV lateral wall activation times (LWAT) and RV free wall activation times (FWAT) were quantified on the apical 4-chamber view for each patient and each pacing protocol. 3D rendering of the ventricular activation maps were then generated by registering the four multi-2D views around the LV base to apex axis of symmetry and performing a linear interpolation circumferentially between them.

Results/Discussion

EWI was shown capable of mapping and distinguishing the electromechanical activation in the three standard pacing protocols arising from CRT (Figure). LWAT in BiV pacing (71 ± 16 ms) were found to be lower compared to LV (94 ± 21 ms) and RV pacing only (123 ± 21 ms). FWAT were the highest in LV pacing (104 ± 17 ms), while RV (74 ± 18 ms) and BiV (72 ± 20 ms) pacing conditions resulted in similar FWAT values. LWAT was significantly different in each of the three pacing conditions ($p=0.05$), while FWAT was able to distinguish between LV pacing and the other two conditions ($p=0.02$). These findings indicate that EWI could be a valuable monitoring tool for clinicians to optimize the pacing vectors after ICD placement and potentially identify super-responders.

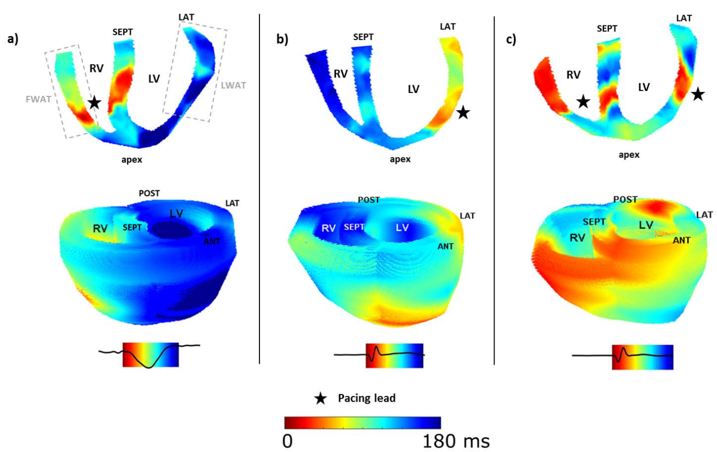

Fig. EWI ventricular activation maps in HF patient undergoing CRT. a) RV pacing only (LWAT = 154 ms, FWAT = 84 ms), b) LV pacing only (LWAT = 84 ms, FWAT = 129 ms), c) BiV pacing (LWAT = 96 ms, FWAT = 57 ms). Top row: four-chamber apical view isochrones, bottom row: 3D rendering of the ventricular activation maps.