REPRODUCIBILITY AND ANGLE INDEPENDENCE OF ELECTROMECHANICAL WAVE IMAGING FOR THE MEASUREMENT OF ELECTROMECHANICAL ACTIVATION DURING SINUS RHYTHM IN HEALTHY HUMANS

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Background: Electromechanical Wave Imaging (EWI) is an ultrasound-based technique that has been shown to directly and non-invasively map the transmural electromechanical activation in all four cardiac chambers in vivo [1]. In previous studies, EWI has been shown reproducible in simulations and canine experiments [2], as well as within same acquisitions across consecutive cardiac cycles in open-chest dogs [3]. However, reproducibility in closed-chest humans has not been investigated. Furthermore, it is critical for clinical applications to reliably measure the activation sequence independently of the imaging view.

Aims: In this study, we demonstrate the reproducibility and angle independence of EWI for the assessment of electromechanical activation during sinus rhythm in healthy humans.

Methods: A 2.5 MHz phased array was used with a Verasonics system (Verasonics, Redmond, WA) to perform EWI on a healthy human heart in three standard echocardiographic views: parasternal long-axis, and apical 4- and 2-chamber. We acquired RF frames successively twice for each view during sinus rhythm for 2 seconds at 2000 frames/s with an unfocused flash sequence at a depth of 20 cm. We estimated the axial incremental displacement and strains using 1D RF cross correlation with a window size of 9.2 mm and a window shift of 0.385 mm, and a least-squares kernel of 5 mm respectively. We defined the wavefront of electromechanical activation as the first time-point at which the incremental strain value changes from relaxation to contraction after the onset of the QRS complex. Activation maps of the zero-crossing timings were generated and compared *1)* within the same acquisition across consecutive cardiac cycles by computing the absolute activation time difference between the two isochrones (Fig.1); *2)* within the same view across successive acquisitions by averaging the activation times through similar myocardium wall regions; and *3)* within equivalent LV regions across different imaging angles by comparing the posterior wall between the parasternal and apical 2-chamber views, respectively the septal wall between the parasternal and apical 4-chamber views.

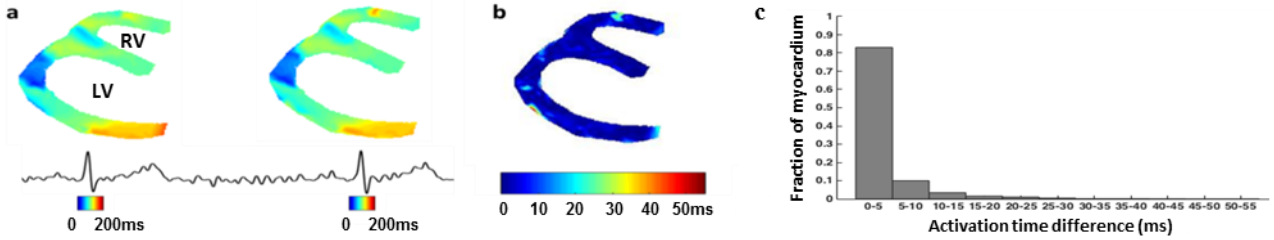

Fig.1: EWI repeatability during SR for healthy subject within same parasternal long-axis acquisition. The origin of the isochrones corresponds to the onset of the QRS complex. (a) Parasternal long-axis view isochrones for two consecutive cardiac cycles. (b) Difference map and (c) histogram of the absolute activation time difference between the two parasternal long-axis isochrones. LV = left ventricle, RV = right ventricle.

Results: *1)* In the 2-chamber view, 90% of the myocardium exhibits activation time differences between the two consecutive isochrones of less than 5 ms (ie. 3% of the maximum activation time), compared to 80% in the parasternal long-axis view (Fig.1). In the 4-chamber view, 50% of the activation time differences fall under 5 ms and 80% are under 10 ms. *2)* Comparison across acquisitions in the same view yielded very similar results. Average activation times in parasternal long-axis and 2-chamber view walls varied by 1.9%, respectively 2.6%. However in the 4-chamber view, we get the highest activation time average fluctuation of 12.4% in the lateral wall, with a small variation of 2.0% for the septal and RV walls. *3)* Finally at different imaging angles, we observed similar isochrone patterns ranging from 25 to 175 ms, even though activation times in specific regions could show discrepancies of up to 35 ms.

Conclusions: EWI was capable of characterizing the SR electromechanical activation and of reliably obtaining the same pattern across different acquisitions and views. These findings indicate that EWI is a reproducible and angle independent technique that can map the electromechanical activation in sinus rhythm in human hearts in vivo.

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