Mechanisms of AF: work in progress on the link between electrical patterns and structural remodeling

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INTRODUCTION Catheter ablation of atrial fibrillation (AF) is a promising therapy, whose success is limited by uncertainty in the mechanisms sustaining arrhythmia, in particular persistent AF. Many theories based on atrial electrical activation or on atrial structural remodeling have been proposed to target AF mechanisms. We hypothesized these two prospective approaches could be linked and the computational analysis of atrial electrical patterns and fibrotic tissue location and extent could give further insights on the role of rotors and spatial relationship between them and atrial fibrosis.

METHODS Eighteen patients with paroxysmal AF were enrolled in the study and magnetic resonance angiography (MRA), delayed-enhanced MR imaging (DE-MRI) and electrograms were acquired. Six of these patients had endocavitary atrial signals acquired using a 64-electrodes contact catheter. Electrical patterns were analyzed by applying the standard procedure based on the Hilbert transform (HT) and with sinusoidal wavelet recomposition (SR). In addition, a new technique based on the research of maximum negative derivative of the unipolar electrograms and a modified version of signal recomposition (NDSR) was tested. Detected atrial activation timings (AAT) and derived parameters were compared with manual annotation performed by an expert cardiologist. An anatomical model was derived by segmenting MRA data applying an edge-based level set approach guided by a phase-based edge detector. A multimodality affine registration was applied to register MRA and DE-MRI data and gray intensity levels from DE-MRI were used as a texture of the 3D model to visualize fibrosis location and quantify its extent.

RESULTS Comparison between AATs detected on a segment basis in 461 signals in sinus rhythm (5252 AATs) applying the three techniques are reported in the table. Mean cycle length duration (MCLD) computed applying SR and NDSR showed an error of 5.1%±4.2% and 3.2%±3.4%, respectively. An example of the NDSR algorithm performance applied to an AF signal is shown in the figure (left panel). An example of the registration step is shown in the figure on the right (A-C) together with a 3D model of the atrium from MRA in one patient with superimposed the information from DE-MRI (D).

	AAT detected	TP	FP	FN	Se (SD)	PPV (SD)
HT	30491	3424	27067	1816	63.2 (19.8)	11.1 (2.5)
SR	5339	1577	3762	3663	29.3 (10.7)	28.5 (9.3)
NDSR	5207	4359	848	881	82.6 (8.9)	83.2 (8.5)

Table. TP: true positive; FP/FN: false positive/negative; Se: sensibility; PPV: positive predictive value

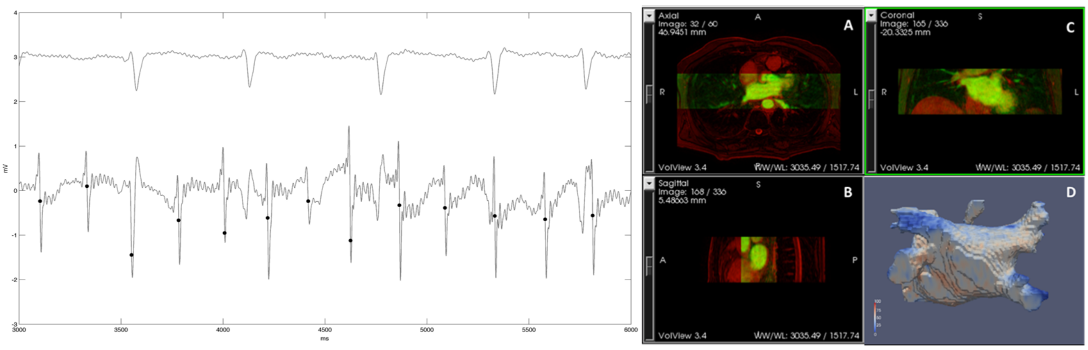

Figure. Left: AATs detected applying NDSR algorithm on an AF signal; right: example of MRA and DE-MRI integration.

CONCLUSION Preliminary results on detected AATs using the newly developed algorithm are promising. Image fusion and integration of information from MRA and DE-MRI is feasible. Next analysis steps include testing of NDSR algorithm on AF signals and comparison of DE-MRI information in 3D with electro-anatomical maps.