Exploring ICA for Differentiating Intracavitary Signals Based on Tissue Composition

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Precise characterization of the cardiac tissue is crucial for diagnosing and treating arrhythmias. In particular, detecting the spatial distribution of fibrotic tissue is key for the understanding of propagation patterns and underlying mechanisms. Although the recent high-density catheters (e.g. HD Grid) provide enhanced mapping capabilities, difficulties still exist in evaluating tissue properties. In the context of intracardiac signals, the statistical technique of independent component analysis (ICA) has been mainly used for noise and artifact removal. We propose a novel application of this technique for the characterization of the cardiac tissue, using unipolar EGMs (HD Grid) acquired during sinus rhythm, collected from a patient with a reablation procedure with postablation fibrotic lesion formed on the anterior wall within several month after the first procedure. Three sets of 16 signals were used, each with an increment in the presence of signals belonging to fibrotic tissue compared to healthy tissue. The analysis carried out using the fastICA algorithm has allowed determining, for the three sets of signals, a set of discriminative ICA sources between the two types of tissue included (Figure 1.A). It has been demonstrated, using kurtosis and reconstructions of the signals (Figure 1.B), that these components hold the highest significance. Discriminating sources and their related reconstructions are then subsequently used for creating archetypes of each tissue's signal and its characterization, obtaining normalized correlation results between these archetypes and the original signals, healthy and fibrotic, of 0.84 ± 0.06 and 0.94 ± 0.01, respectively. Therefore, the presented novel multivariate approach holds potential as an additional tool for tissue characterization and discrimination under different conditions of atrial tissue.

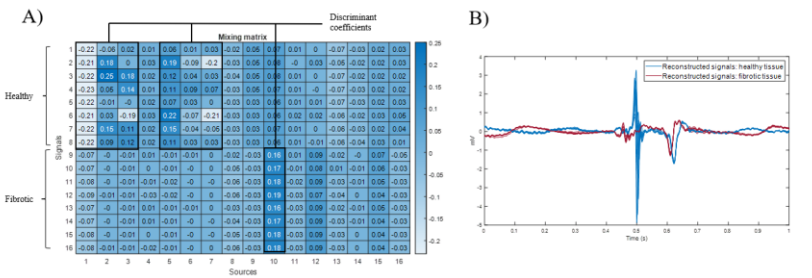

Figure 1: A) Mixture matrix obtained from the FastICA algorithm. The discriminant sources are selected by comparing both healthy tissue and fibrotic tissue coefficients. B) Reconstructed signals with the sources selected.