Clustering of time-evolving frequency patterns in atrial fibrillation on the surface electrocardiogram

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Aims. Previous studies have shown that atrial fibrillation (AF) is characterised by short-term (10-20s) stable propagation patterns. We sought to investigate whether frequency patterns are discernible on surface ECG and quantify the stability of these patterns before and after wide circumferential isolation of pulmonary veins (WPVI) in persistent AF.

Methods. The study included 40 patients (63±10 years, sustained AF 11±7 months) who underwent a de-novo WPVI. ECG signals were recorded at baseline and end of ablation (end_WPVI, before cardioversion or conversion of AF into sinus rhythm), and QRST waves were subtracted. Instantaneous frequency (IF) was estimated on 60-sec epochs using an adaptive harmonic frequency tracking scheme. For each patient, IF vectors were created by taking the samples from all precordial lead IFs at each time instant. Hierarchical clustering of IF vectors was performed using linkage method for an optimal number of clusters (Calinski-Harabasz criterion). The maximum run-length of clusters was then computed.

Results. The optimal number of clusters to assess the temporal frequency patterns was the same at baseline and after WPVI (Panel A: BL 2.8±1.4, endWPVI 3±1.2, p = ns). The maximum run-length of clusters was similar at baseline and end of ablation (Panel B: BL 18±6[s], endWPVI 19±9[s], p =ns), suggesting a lack of PVs contribution to the frequency patterns on surface ECG.

Conclusion. Clustering analysis of precordial instantaneous frequencies provides information about the temporal unfolding of atrial fibrillation. Duration of temporally stable frequency patterns on surface ECG has a typical value of 20 s, which is not impacted by PVI ablation.