Atrial fibrillation (AF) is the most frequently diagnosed arrhythmia, characterized by an uncoordinated atrial electrical activation, thus causing the atria to be unable to pump blood effectively. The prevalence of AF is expected to increase significantly in the next decades as the population ages. However, both the knowledge and the treatment of this arrhythmia still have to experiment a significant progress. Previous studies have reported that AF organization, which can be defined as the repetitiveness degree of the atrial activity pattern, correlates with the arrhythmia status as well as with the therapy outcome. Thus, estimating AF organization from surface electrocardiographic (ECG) recordings constitutes a very interesting approach because ECG recordings are easy and cheap to obtain.

The objective of this doctoral thesis is to assess the use of a variety of nonlinear indices in the estimation of AF organization from single-lead noninvasive ECG recordings. Apart from the most common noninvasive AF organization estimators, such as Sample Entropy (SampEn) and the dominant atrial frequency (DAF), the following nonlinear indices have been studied: Fuzzy Entropy, Spectral Entropy, Lempel-Ziv Complexity and Hurst Exponents. Moreover, since the presence of noise and ventricular residuals affects the performance of nonlinear methods, the application of a strategy aimed at reducing these nuisances has been evaluated. Therefore, the application of these metrics over the atrial activity fundamental waveform, named the main atrial wave (MAW), has been proposed. In this doctoral thesis, the following scenarios involving AF organization have been considered: the prediction of paroxysmal AF spontaneous termination, the study of the earlier signs anticipating AF termination and the classification between paroxysmal and persistent AF from short ECG recordings.

Firstly, the performance of the studied metrics discriminating events related to AF organization was tested making use of a reference database aimed at predicting AF spontaneous termination. In this study, most of the proposed indices provided higher accuracy than traditional AF organization estimators. Accuracy values higher than 90% were obtained with several indices. In particular, the generalized Hurst exponents of order 1 and 2, $H(1)$ and $H(2)$, achieved outstanding results, thus being selected for later studies in this thesis. Furthermore, the computation of $H(2)$ depends on two critical parameters, namely, the analyzed interval length (L) and the maximum search window for self-similarities (tau). Hence, a study with 660 combinations on these two parameters was performed, together with the sampling frequency (fs) of the recording, in order to obtain their optimal combination in computing AF organization. On the other hand, previous works analyzing the spontaneous termination of AF have been only focused on the last 2 minutes preceding the termination. In contrast, a different scenario considering longer recordings to detect the earlier signs anticipating paroxysmal AF termination has been analyzed for the first time in this thesis. $H(2)$ was selected for the study because of its highest accuracy in AF termination prediction. Additionally, the DAF and SampEn were also computed as references. Through this study it has been corroborated that AF organization only varies significantly within the last 3 minutes before spontaneous termination. As a consequence, the early prediction of paroxysmal AF spontaneous termination does not seem feasible through the current signal analysis tools. Finally, $H(2)$ was applied in the classification between paroxysmal and persistent AF from short ECG recordings, achieving a higher diagnostic accuracy than DAF and SampEn. This result suggests that the analysis of ambulatory ECG recordings through $H(2)$ could be a future

alternative to the use of Holter ECG recordings in the classification between paroxysmal and persistent AF.

An accurate quantification of AF organization in a straightforward way is crucial in determining the current progression of AF in every single patient. Given that the treatment of AF still is based on trial and error strategies, the present doctoral thesis aims at providing new insights in organization quantification, thus leading to useful clinical diagnostic techniques and aid tools with valuable contributions to tailored therapies of patients in AF. Future applications of the studied indices in different scenarios may also provide useful clinical information and contribute to the improvement of AF management, thus reducing costs for the healthcare providers and risks for the patients.