Atrial Electrogram Complexity as a Clinical Instrument for Measuring Temporal Fractonation Variability during Atrial Fibrillation

Tiago P Almeida¹, João L Salinet Jr¹, Gavin S Chu², G André Ng², Fernando S Schlindwein¹

¹Department of Engineering, University of Leicester, Leicester, UK  
²Department of Cardiovascular Sciences, Glenfield Hospital, Leicester, UK

Introduction

Regions of the atria with complex fractionated atrial electrograms (CFEs) have been suggested to represent remodelled atrial substrate, and hence important sites for ablation in patients with persistent AF [1]. However, temporal behaviour of complex fractionated atrial electrograms (CFEs) remains ill defined [2].

In this study we introduce Negentropy (NegEn) as a measurement of electrogram (EGM) complexity and compare its use in measuring CFEs temporal behaviour with current algorithms based on time domain.

Methods

Five patients with persistent AF undergoing catheter ablation (L/R WACA) had bipolar EGM pre and post ablation recorded over 48 s using a decapolar catheter placed in the coronary sinus (Bandpass: 30 - 250Hz; Notch: 50Hz). Signals with strong ventricular far-field influence were excluded. A total of 28 EGMs were analysed. Each EGM was segmented into 8 time windows of 8 s duration with no overlap. A script based on EnSite NavX criteria was developed in MATLAB, as illustrated on Figure 1. EGMs were considered fractionated if 30 ms ≤ CFEmean ≤ 120 ms [3].

NegEn is an objective measurement of the amplitude distribution of a signal reflecting the complexity of EGMs [4]. High NegEn reflects organized atrial activity and low NegEn reflects fractionation, as illustrated on Figure 2.

CFEmean and NegEn were calculated for each segment. The percentage of segments labelled as fractionated per EGM was calculated, according to CFEmean criteria. If 80% or more of the segments within one EGM were labelled as fractionated, the EGM was considered fractionated; if 20% or less of the segments were labelled as fractionated, the EGM was considered not fractionated; if 20% - 80% of the segments were labelled as fractionated, the EGM was considered to lack temporal stability (non-stable). The coefficient of variation (%CV) defined as the relative standard deviation ($\sigma/\mu$), was found for each EGM based on each metric, CFEmean and NegEn, in order to assess the temporal behaviour of the EGMs.

Results

Figure 3A illustrates the CFEs temporal behaviour for 3 EGMs (EGM1 – non-fractionated; EGM2 – non-stable; EGM3 – fractionated) according to CFEmean and NegEn. NegEn showed to be more sensitive to EGM temporal behaviour with constantly higher CV when compared to CFEmean. Figure 3B shows the 8 s EGM segment from the highlighted instant.

Figure 4A shows a significant increase (p=0.004) in the CFEmean pre- to post-ablation (14 EGMs pre- and 14 EGMs post-ablation). Figure 4B assesses the overall CFEs temporal behaviour pre- and post-ablation. Figure 4C highlights the EGM temporal behaviour (1-fractionated, 2-non-fractionated or 3-non-stable) based on the %CV pre- and post-ablation according NegEn and CFEmean.

Conclusions

Both CFEmean and NegEn are able to categorize CFE temporal behaviour. The results suggest that NegEn is more sensitive to CFE temporal variability than current time domain algorithms. This new approach could increase the ability to measure CFE temporal behaviour objectively, which would help to identify relevant ablation targets.

References


Correspondence to Tiago Almeida
Email: tpda1@le.ac.uk

Figure 1. MATLAB script based on NavX criteria

Figure 2. Electrogram complexity assessed by NegEntropy

Figure 3. CFEmean and NegEn temporal behaviour with its respective coefficient of variation

Figure 4. A. CFEmean (pre-post-ablation); B. CFE overall temporal behaviour and C. coefficient of variation for both NegEn and CFEmean.