Title: Characterization of EGF-Identified Source Signatures in Sinus Rhythm and Atrial Fibrillation

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ABSTRACT:

Background
One mechanism of initiation and propagation of atrial fibrillation (AF) may depend on rapid atrial stimulation from focal sources. Whether arrhythmogenic mechanism at these foci is abnormal automaticity, triggered activity, or microreentry is unclear; however, after activation emerges from these driver sites, fibrillatory conduction results in clinical AF. Electrographic Flow (EGF) mapping visualizes global atrial wavefront propagation in near real-time and has been used to identify areas of centrifugal flow as sources of AF.

Objectives
Characterize EGF patterns of electrical activation across atrial endocardium during sinus rhythm (SR) v. during AF driven by active EGF-identified sources.

Methods
FLOW EVAL-AF is a single-center, prospective study of 10 patients with paroxysmal or persistent AF who underwent EGF mapping with a 64-pole basket catheter. During AF, unipolar electrograms were recorded from the basket for 1 min in 6 biatrial locations per patient and a corresponding set of 1 min recordings were taken from the same locations in SR. EGF algorithm detects sources as origins of excitation from a singularity of flow vectors that emanate from this location. The flow estimation step is a sequence of vector field estimates where Euclidean vector length represents a measure of consistency of observed wavefront patterns called Flow Consistency (FC).

Results
A total of 10 patients were enrolled. Mean age was 69±10 years; 1 patient was female; mean left atrial (LA) diameter was 4.6±0.5 cm. For the same patient and atrial locations, FC was significantly higher in SR than in AF (0.96±0.11 v. 0.60±0.06, p=0.02). For an individual patient, areas of high FC in AF were not correlated to areas of high FC in SR. Eleven areas of AF source activity (SAC) were detected—7 in LA and 4 in RA. Mean SAC was 32±0.09%. In 8 of 11 (73%) locations where active sources were identified during AF, electrographic flow converged into a “sink” region at a location within 1 electrode distance of the source; 5/7 (71%) were in LA and 3/4 (75%) were in RA. Mean SAC was higher among sources that became sinks compared with those that did not (34±10% v. 27±4%, p=0.14).

Conclusions
Electrographic flow patterns vary significantly in both magnitude and direction depending on the rhythm. AF sources emanate flow during ongoing AF, but when inactivated during SR, appear more as flow sinks possibly due to surrounding abnormal substrate with slow and/or anisotropic conduction due to arrhythmogenic remodeling.

Figure:

A) Paired EGF maps recorded from the same 64-electrode basket position in the left atrium in both atrial fibrillation (AF) and sinus rhythm (SR). EGF mapping algorithm detects sources as divergent electrical activation starting from a singularity of flow vectors (D2). Flow sinks are characterized by a convergence of flow vectors from a minimum of 4 orthogonal directions as identified on the sinus rhythm (SR) recordings (D2). Flow consistency (FC) is represented by the Euclidean length of the flow vectors, i.e., the longer the vector, the higher the consistency of the observed wavefront patterns (more magenta). Mean FC is annotated at the top-left of each EGF Map.

B) Another pair of EGF maps recorded from the same basket position in the right atrium in both AF and SR. In AF, a source is present at D4 and emanates chaotic, though divergent activation wavefronts; however, in SR, highly consistent and stable flow through the same region converges into D3. As visually apparent in the example below, while global FC in a particular region of atrial endocardium increases from AF to SR, it does not increase uniformly through the tissue suggesting the presence of underlying difference in tissue conduction properties.