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EDITORIAL: HIGH DENSITY MAPPING OF ATRIAL FIBRILLATION SOURCES

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Keywords

Atrial fibrillation; High-density Mapping; Ablation; Phase Mapping

1.0 Introduction

Cardiac fibrillation has unclear mechanisms, but localized AF sources have now been confirmed by high density optical imaging of human AF [1,2], and mechanically in VF by speckle tracking echocardiography [3], as well as numerous clinical studies. Nevertheless, ablation of AF drivers shows mixed albeit promising results in meta-analyses [4,5]. The reasons for variability between these clinical studies are unclear but likely involve differences in the importance of driver mechanisms between individual AF patients and, importantly, differences in methods for detecting AF rotors and focal sources. While several methods now show rotational patterns in AF [6–8], including sites where ablation may terminate AF, further work is needed to reconcile why they may show differing patterns of temporal stability or spatial meander even at sites of physiological impact and in the same datasets [9].

2.0 High-density Phase Mapping

In this issue of JCE, Viera *et al* report a use of the Rhythmia high-density mapping system to identify rotors and focal impulses at sites where ablation terminated AF in a porcine model. Animals that developed sustained AF from rapid atrial pacing were mapped to reveal fractionated and abnormal electrograms in the RA. Ablation of these sites was performed until AF termination or until all electrograms were eliminated. Offline, similarity indices of electrogram shape (SI), dominant frequency (DF), and rotor/focal impulses were concurrently evaluated using custom software. Rotational and focal sources (0.43 ± 0.76 per chamber) were found only at sites of high SI (total of 1.67 ± 0.87 SI sites per chamber). 64 abnormal electrogram sites were ablated in 16 AF episodes in 14 animals. 11 (17%) ablated sites led to termination and, of these, 6 (54.5%) harbored both high SI and rotors/focal

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Disclosures:

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impulses. AF terminated with ablation at all 6 rotor sites. Rotors were not found at 53 ablated fractionated sites (83%). Fractionation was non-specific for AF termination as in prior studies [10] and was extensive (67% of mapped atria), yet 11/16 AF events were terminated by ablation at sites of fractionation in the RA. Histopathology showed no differences in regional fibrosis of the RA related to these findings.

3.0 Interpretation and Limitations

This is among the first uses of Rhythmia to identify rotors and focal impulses in AF. While this system does not provide panoramic imaging, it has the potential to improve electrogram detail compared to other mapping studies. It is intriguing that colocalization of rotor/focal sources with CFAE associated with all cases of AF termination in this retrospective analysis, although the imperfect sensitivity means that prospective validation is key. One clear limitation with this approach is that sampling the atria piecemeal means that sources may be missed if intermittent at the time that location is mapped [12]. This may explain the relatively small numbers of rotors/focal sources in this dataset (0.43 per chamber). Ripple mapping also is limited by discontinuities in recording due to filtering “accepted” and “rejected” beats. The authors report that AF was mapping for 6.17 ± 4.29 min, yet only 581 ± 387 beats were accepted, suggesting 4–8 beats are rejected for each accepted beat. These discontinuities may reduce sensitivity for temporally fluctuating or spatially precessing sites [12] and limit detection to only the most stable AF sources. Prospective studies are required to determine if this is beneficial (by ‘filtering’ out transient sites) or a limitation. Another limitation is the unclear validity of this porcine model for human AF, and the use of RA mapping only, which accounts for only $\sim 1/3$ of sources in human AF studies using several methodologies [11]. In addition, rotors were defined visually without quantitative metrics, and no measure of agreement between reviewers was provided. Finally, there was a limited analysis of the role of fibrosis which would be interesting to study.

4.0 Conclusions

This study identifies AF rotors and focal sources using a high-density mapping catheter *in vivo* which, combined with electrogram analysis, provided a high specificity for sites of AF termination by ablation. While this retrospective analysis should be followed by prospective studies in patients, these data add to the literature on AF driver detection. Further work is required to validate the clinical use of high-density piecemeal mapping of the atrium to identify critical rotational and focal sources of AF, and to compare results for continuous, panoramic mapping methods. We eagerly await such comparative studies to reconcile the observed variability in AF mapping and ablation results.

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5.0 References

- [1]. Gray R, Pertsov A, Jalife J. Spatial and temporal organization during cardiac fibrillation. *Nature* 1998;392:75–78. [PubMed: 9510249]
- [2]. Hansen BJ, Zhao J, Csepe T a., Moore BT, Li N, Jayne L a., et al. Atrial fibrillation driven by micro-anatomic intramural re-entry revealed by simultaneous sub-epicardial and sub-endocardial optical mapping in explanted human hearts. *EHJ* 2015;36:2390–2401.
- [3]. Christoph J, Chebbok M, Richter C, Schröder-Schetelig J, Bittihn P, Stein S, et al. Electromechanical vortex filaments during cardiac fibrillation. *Nature* 2018;555:667–672. [PubMed: 29466325]
- [4]. Ramirez FD, Birnie DH, Nair GM, Szczotka A, Redpath CJ, Sadek MM, et al. Efficacy and safety of driver-guided catheter ablation for atrial fibrillation: A systematic review and meta-analysis. *JCE* 2017;28:1371–1378.
- [5]. Baykaner T, Rogers AJ, Meckler GL, Zaman J, Navara R, Rodrigo M, et al. Clinical Implications of Ablation of Drivers for Atrial Fibrillation. *Circ: AE* 2018;11:e006119.
- [6]. Swerdlow M, Tamboli M, Alhusseini MI, Moosvi N, Rogers AJ, Leef G, et al. Comparing phase and electrographic flow mapping for persistent atrial fibrillation. *PACE* 2019;pace.13649.
- [7]. Podziemski P, Zeemering S, Kuklik P, van Hunnik A, Maesen B, Maessen J, et al. Rotors Detected by Phase Analysis of Filtered, Epicardial Atrial Fibrillation Electrograms Colocalize With Regions of Conduction Block. *Circ: AE* 2018;11:1–12.
- [8]. Knecht S, Sohal M, Deisenhofer I, Albenque J-P, Arentz T, Neumann T, et al. Multicentre evaluation of non-invasive biatrial mapping for persistent atrial fibrillation ablation: the AFACART study. *Europace* 2017;1–8. [PubMed: 27302390]
- [9]. Alhusseini M, Vidmar D, Meckler GL, Kowalewski CA, Shenasa F, Wang PJ, et al. Two Independent Mapping Techniques Identify Rotational Activity Patterns at Sites of Local Termination During Persistent Atrial Fibrillation. *JCE* 2017;28:615–622.
- [10]. Lau DH, Maesen B, Zeemering S, Kuklik P, Hunnik A Van, Lankveld TAR, et al. Indices of bipolar complex fractionated atrial electrograms correlate poorly with each other and atrial fibrillation substrate complexity. *Heart Rhythm* 2015;12:1415–1423. [PubMed: 25771914]
- [11]. Zaman JAB, Rogers AJ, Narayan SM. Rotational Drivers in Atrial Fibrillation - Are Multiple Techniques Circling Similar Mechanisms? *Circ: AE* 2017;10:e006022.
- [12]. Kowalewski CA, Shenasa F, Rodrigo M, Clopton P, Meckler G, Alhusseini MI, et al. Interaction of Localized Drivers and Disorganized Activation in Persistent Atrial Fibrillation. *Circ: AE* 2018;11:e005846.