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EDITORIAL

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# Editorial to "Diverse activation patterns during persistent atrial fibrillation by non-contact charge-density mapping of human atrium"

Atrial fibrillation (AF) is the most commonly encountered and troublesome arrhythmia in clinical practice. The pulmonary veins (PVs) are major sources of AF. PV isolation has become the corner stone of AF ablation, but still has not been standardized because variable AF mechanisms make identifying of AF sources using conventional approaches difficult. Previous reports suggested that automatic focal discharges, multiple reentrant wavelets, and single reentry with fibrillatory conduction may play roles in initiating and perpetuating AF. However, the efficacy of adjunctive ablation strategies including non-PV triggers elimination, stepwise linear ablation, targeting areas with complex fractionated electrograms, low-voltage areas, ganglionated plexi, focal impulses, and rotational activity, and left atrial appendage isolation in addition to PV isolation have been reported, but the clinical outcomes after long-term follow-up have been inconsistent and suboptimal. Currently, clarification of the patient-specific mechanisms responsible for AF initiation and perpetuation is a challenging issue. Conventional mapping has some limitations in mapping AF drivers, because of its limited resolution and the need for sequential point-by-point acquisitions. Favorable ablation outcomes of persistent AF will depend upon the ability of mapping systems to provide globally, temporally, and spatially high-resolution signal acquisitions to find additional arrhythmogenic non-PV areas. Currently, several global mapping systems using offline- or online-specific algorithms have been developed to localize AF sources. Each system possesses specific advantages and disadvantages and requires careful interpretation of the mapping data.

The noncontact mapping system (EnSite Array, Abbott Laboratories) using 64-unipolar-electrodes has been reported to have specific advantages for global simultaneous mapping of complex activations due to its capability of single-beat analyses.[1] Although the noncontact mapping system has a clear advantage for identifying non-PV triggers and unstable macroreentry maintaining AF as compared to other mapping systems, this system has several limitations for mapping AF. First, the accuracy of the inversely calculated reconstructed electrograms from the area with a distance of more than 40 mm from the balloon center may be unreliable. Therefore, virtual electrograms may limit its accuracy in cases with large atrial chambers. Second, operators frequently encounter difficulty in manipulating ablation catheters along with the Array balloon inside chambers. The above-mentioned problems may have restricted the widespread practical use of this system.

The noninvasive body surface mapping system (CardioInsight, Medtronic) using an external vest mounted with 252 electrodes and phase mapping algorithms in conjugated with computed tomography can visualize biatrial 3D activations to localize AF drivers.[2] Favorable clinical outcomes of a driver-targeted ablation of persistent AF using this system have been reported from limited laboratories. This system has the following limitations: first, the detection of pseudo-drivers due to the nature of phase-based analyses; second, the difficulty in differentiating drivers arising from the right- and left-sided interatrial septum; and third, the lack of direct 3D navigation of ablation catheters for identifying AF drivers.

The RhythmView Mapping System (Abbott Laboratories) consists of a 64-electrode contact mapping basket catheter with a phase mapping algorithm. This system can visualize focal AF drivers and guide focal impulse and rotor modulation (FIRM guided ablation).[3] However, the clinical outcomes of these ablation strategies have not been consistent and widely vary between laboratories. Inadequate contact and unevenly distributed electrodes due to distorted basket splines, especially at the mitral annulus and left atrial appendage can cause misinterpretation of collected data causing artifactual identification of nonexistent AF drivers and missing true drivers. Furthermore, this system does not provide 3D navigation of catheters. These issues can be possible reasons for the inconsistent results of FIRM guided ablation.

Recently, the novel noncontact dipole density mapping system (AcQMap, Acutus Medical) has been developed. This system requires an AcQMap catheter, formed by six splines with 48 biopotential electrodes and can create activation maps onto 3D geometries reconstructed by 48 ultrasound transducers. This system can visualize the intracardiac activation using a potential field rather than using a phase transformation without the need for catheter contact. A preliminary study demonstrated that the dipole density (unit, μCoulombs/cm) represents an actual biophysics of cardiac activity that is sharper and narrower than the voltage, so that it can provide a more discrete wavefront propagation.[4] In this issue of the *Journal*,

Rui Shi et al retrospectively analyzed and characterized activation patterns of persistent AF using this system.[5] The main findings described in this paper were as follows: (a) Persistent AF is characterized by highly dynamic and heterogeneous activation patterns consisting of localized irregular activation (LIA) (63%), localized rotational activation (LRA) (20%), and focal with centrifugal activation (FCA) patterns (17%); (b) a combination of slow/accelerated conduction, pivotal activation, and collisions were observed; (c) preferential conduction areas with repetitive LRA and LIA were detected in the mid-anterior (48%) and lower-posterior (40%) LA wall; and (d) observations of transitions between LIA and LRA with merging and breaking of wavefronts were noted. The authors proposed that persistent AF can be maintained by the coexistence of LIA, LRA, and FCA with each pattern influencing the other depending on the anatomic and functional properties of the atrial substrate. This was a well-conducted study suggesting that alternatives to phase mapping using local activation may assist in targeted ablation of persistent AF. Although these observations are provocative and potentially important, there are several important limitations to this retrospective analysis. The authors suggested dynamic spatial dispersion of atrial refractoriness may cause the formation of diverse wavefront activations, but the electrophysiological mechanism of these phenomenon remains unclear. Furthermore, the relative contribution of each diverse activation pattern to the initiation and maintenance of AF remains unknown. Although the authors also suggested that this novel mapping system can allow not only focal triggers but also reentrant AF driver mapping, which can be targeted to improve ablation outcomes. Currently, still several uncertainties remain regarding differentiating between true AF drivers and pseudo ones. Therefore, long-term clinical outcomes evaluated by prospective randomized multicenter trials are required to confirm the efficacy of the AcQMap system in detecting AF sources with a high sensitivity and specificity. In aggregate, further investigation of the systematic identification of AF triggers and drivers and adequate elimination of these critical substrates with precise detection algorithms will improve the overall AF ablation outcomes.

## CONFLICT OF INTEREST

The following author have potential conflicts of interest: SH is a consultant to Japan Life Line and Johnson & Johnson, and received speaker's honoraria from Japan Life Line, Medtronic, Abbott, Bayer, Biotronik, Boehringer-Ingelheim, Bristol-Myers, Daiichi-Sankyo Pharmaceutical Company, and Pfizer.

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