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CASE REPORT

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Successful modulation of atrial fibrillation drivers anchoring to fibrotic tissue after box isolation using an online real-time phase mapping system: ExTRa Mapping

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Abstract

A 41-year-old man with persistent atrial fibrillation (AF) underwent radiofrequency (RF) catheter ablation using an online real-time phase mapping system: ExTRa Mapping. Box isolation could not terminate AF. Subsequently, RF applications on nonpassively activated areas (NPAs), where rotational activations were frequently observed, at the posterior bottom of left atrium outside of box lesion could convert AF to common atrial flutter. Of interest, the NPA near the posterior bottom were located on the patchy fibrotic tissue area assessed by the late-gadolinium enhancement magnetic resonance imaging. This indicated the possibility of the critical AF rotor meandering through the fibrotic tissue area.

KEYWORDS

atrial fibrillation, atrial fibrillation drivers, late gadolinium enhancement magnetic resonance imaging, phase mapping

1 | INTRODUCTION

Pulmonary vein isolation (PVI) has proven to be a useful strategy for radiofrequency catheter ablation (RFCA) of atrial fibrillation (AF) worldwide.[1] However, persistent AF is thought to represent a condition that is also dependent on electroanatomical changes within the atria that are responsible for AF perpetuation.[2] Recently, modulation of AF drivers after PVI has been proposed as one of the effective ablation strategies for persistent AF.[3] We hereby described a case with successful modulation of the AF drivers detected by online real-time phase mapping system: ExTRa Mapping and would like to discuss the relationship between the AF driver and pre-existing fibrotic substrate.

2 | CASE REPORT

A 41-year-old man was documented for atrial fibrillation (AF) on medical checkup. He had no symptoms but hoped to treat AF because of his family history of ischemic stroke due to AF. Although no structural heart disease could be detected by any imaging modality including cardiac ultrasound or late gadolinium

enhancement magnetic resonance imaging (LGE-MRI), LGE areas were found at the lateral wall and posterior bottom of the left atrium (LA), which was likely characterized by dense and patchy fibrotic enhancement, respectively. The patient was placed under light sedated state using dexmedetomidine and fentanyl. To find the location of AF drivers, nonpassively activated areas (NPAs), where rotational activations were frequently observed, were automatically detected by the ExTRa Mapping. In this case, NPAs were distributed at the septum near mitral annulus (MA) and the posterior bottom of LA, but not at the lateral wall. The value of the "nonpassively activated ratio (%NP)" was calculated as 70% and 62% at the septum near MA and the posterior bottom, respectively, while %NP was only 23% at the lateral wall (Figure 1A,B). Box isolation was initially performed during ongoing AF with an irrigated tip RF ablation catheter (TactiCath; Abbott) guided by a three-dimensional mapping system (EnSite NavX system; Abbott Laboratories). Although the electrograms at the LA posterior wall could be completely eliminated, this could not terminate AF. Therefore, NPA-targeted ablation was attempted. RF application was performed by dragging technique filling the NPA (25-30 watts for 10-20 seconds per ablation point, thus 4-5 minutes per NPA), which was consistent with the previously published ablation protocol.[4] Further RF applications on the NPA at the septum near MA could not terminate AF, while subsequent RF applications on the NPA at the posterior bottom could convert AF to common atrial flutter (common AFL) (Figure 2). Cavotricuspid isthmus ablation was performed and bidirectional block was confirmed. At the end of the procedure, programmed stimulation could no longer induce any arrhythmias. Of interest, the NPA near the posterior bottom was concordant with the patchy fibrotic area assessed by LGE-MRI. He has been free from any tachycardia recurrence.

3 | DISCUSSION

This patient with persistent AF changed to common AFL immediately after RF applications for NPAs detected by the online real-time phase mapping system. Recently, Ashihara et al have developed an online real-time phase mapping system (ExTRa

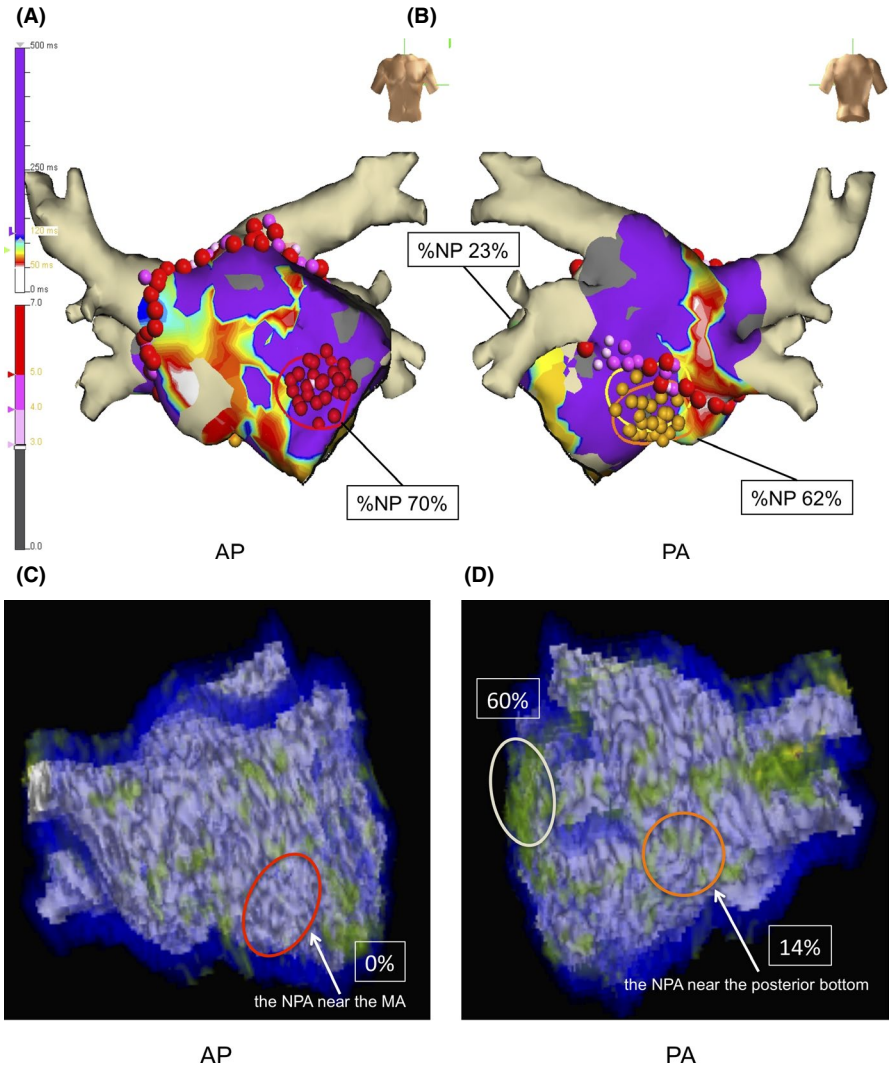

FIGURE 1 CFAE and ExTRa Mapping on the NavX system in the AP (A) and PA (B) views. The 3D ablation tags were colored by red, pink, light pink, and gray according to the LSI values (red: >5; pink: >4; light pink: >3; gray: <3.0). The red, orange, and yellow circles indicated the area with high %NP of 70, 62, and 60%, respectively. The 3D red (near the MA) and yellow (at the posterior bottom) tags in the circles indicated the ExTRa Mapping–guided ablation points. Preoperative LGE-MRI of the LA in the AP (C) and PA (D) views. The green color areas indicated delayed enhancement areas. The red and orange circles correspond to those in panel A and C. The number indicated that the ratio of enhanced area. According to the value, the tissue property at the areas circled by the red, orange, and gray were considered as healthy tissue, patchy fibrosis, and dense fibrosis, respectably. AP, anterior-posterior; CFAE, complex fractionated atrial electrograms; CS, coronary sinus; LA, left atrium; LGE-MRI, late-gadolinium enhancement magnetic resonance imaging; LSI, lesion size index; MA, mitral annulus; NPA, nonpassively activated area; PA, posterior-anterior; %NP, nonpassively activated ratio

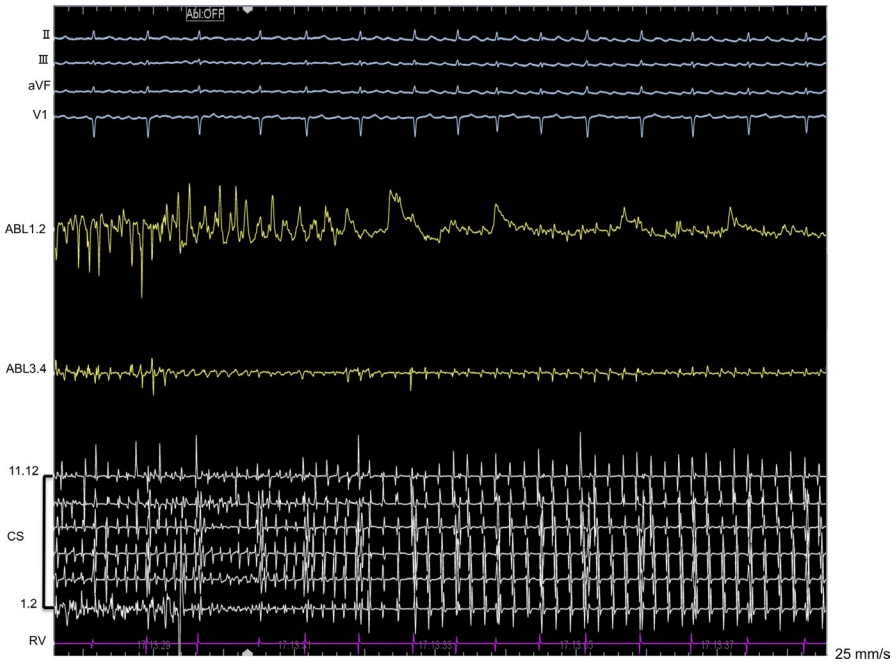

FIGURE 2 Intracardiac recording during RF application on the high %NP area at the posterior bottom. AF was converted to common AFL immediately after the RF application. Video S1 demonstrated the relevant ablation movie. ABL, ablation catheter; AF, atrial fibrillation; AFL, atrial flutter; CS, coronary sinus; RF, radiofrequency; RV, right ventricle

Mapping™; Nihon Kohden Co.).[4] This phase mapping system is characterized by the automatic creation of each phase map movie based on the 5-second wave dynamics during AF. Moreover, they indicated that persistent AF encountered in clinical practice was mostly driven by spatially and temporally unstable rotors that is meandering rotors, rather than stationary stable rotors.[4] ExTRa Mapping could detect such rotational activations, which were defined as NPAs. The frequency of the rotational activations was quantitatively assessed according to the value of the %NP and the distribution of the NPAs within the LA could be evaluated in real-time. Although the recording time of "5 seconds" was likely short, time-reproducibility of %NP was high, which would enable the rapid and accurate AF rotor mapping.[4] In contrast, development and progression of atrial fibrosis are considered to be the substrate for AF perpetuation. LGE-MRI has been developed to visualize and quantify extent of pre-ablation atrial fibrosis as well as post-ablation scar. LGE areas in the current case were considered to be pre-ablation atrial fibrosis because the LGE-MRI was performed before the ablation procedure. In this case, LGE areas were found at the lateral wall and the posterior bottom. To characterize those two enhancement areas, the ratio of enhancement area, which was defined as a signal intensity of >1SD, was calculated. The ratio of enhancement area at the lateral wall was significantly greater than that at the posterior bottom (60% vs 14%) (Figure 1C,D). This indicated that the tissue property at the lateral wall and the posterior bottom was characterized as dense and patchy fibrosis. Computer simulation could excellently demonstrate that AF drivers were observed at the patchy fibrotic tissue, but not at the dense one.[5] Thus, the patchy fibrosis at the posterior bottom was considered to harbor the AF driver. Indeed, RF application there could eliminate AF. This finding was completely consistent with the results from the computer simulation model. Of interest, the value of %NP at the lateral wall with a dense fibrotic property was only 23%. Therefore, we speculated that the areas with patchy fibrotic tissue property as well as high %NP values might be associated with the critical AF driver. As compared to the previous study, the dose of 0.1 mmol/kg gadolinium was relatively low, which indicated that the atrial fibrosis could be underestimated. However, we focused on visualizing the area with "patchy" fibrotic property harboring AF driver. Cardiac MRI with low dose gadolinium of 0.1 mmol/kg might be acceptable for detecting AF substrate.

This suggested that ExTRa mapping and LGE-MRI analysis could visualize the electrical and structural remodeling perpetuating AF and establish the catheter ablation tailored to patients with different remodeled stages. Further studies should be needed to elucidate these issues.

4 | CONCLUSIONS

We experienced a case with successful modulation of AF drivers using ExTRa Mapping and LGE-MRI analysis. NPAs within the patchy fibrotic tissue areas might be one of the critical substrate perpetuating AF. Imaging modality, such as ExTRa Mapping and LGE-MRI, was useful to accurately identify the electrical and structural atrial remodeling and might improve the rhythm outcome in patients with progressed AF.

CONFLICT OF INTEREST

KH chairs the Section, and KF and KK belong to the Section. The authors have reported that they have no relationships relevant to the contents of this paper to disclose.

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SUPPORTING INFORMATION

Additional supporting information may be found online in the Supporting Information section at the end of the article.

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