ATRIAL FIBRILLATION

COMPLEX CASE STUDY

A Focal Impulse and Rotor Mapping (FIRM) Ablation Approach for Recurrent Persistent Atrial Fibrillation

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ABSTRACT. Focal impulse and Rotor Modulation (FIRM) has been introduced recently as a new approach for ablation of atrial fibrillation (AF). We report a case of FIRM-guided rotor ablation, performed in combination with (re)-pulmonary vein isolation in a patient with recurrent persistent AF and two previous failed conventional ablation procedures. Four rotors could be detected and successfully ablated in this patient, one in the right atrium and three in the left atrium. Notably, the patient experienced a short-term recurrence of AF with spontaneous conversion back to sinus rhythm 11 weeks after the procedure. However, now the patient has been in stable sinus rhythm for 19 months. This case highlights the need to effectively address the specific AF mechanisms, especially in patients with recurrent persistent atrial fibrillation. FIRM-guided rotor ablation seems to be a beneficial option for these patients.

KEYWORDS. Atrial fibrillation, catheter ablation, FIRM, rotor, spiral wave.

Introduction

Although pulmonary vein isolation (PVI) is widely accepted as the treatment of choice for patients with paroxysmal atrial fibrillation (AP),1–3 there has been no broad consensus regarding the most effective ablation strategy for non-paroxysmal AF, in part due to the lack of consensus regarding the mechanism(s) underlying its maintenance. It is conceivable that non-responders to conventional ablation are in fact able to sustain normal sinus rhythm, but simply require a procedure that more effectively targets the patient-specific mechanisms that maintain and perpetuate that patient’s arrhythmia. The presence of rotors in human AF was recently reported, demonstrating that AF was driven by spatially and temporally stable rotational drivers, and the targeted ablation of those drivers/rotors was able to terminate the AF.4 This suggests that a patient-tailored approach focused on the elimination of these rotors may be a more advisable procedure for patients with recurrent non-paroxysmal AF who are refractory to other interventions.

We report on a case of FIRM-guided rotor ablation, performed in combination with (re)-PVI, in a patient with recurrent persistent AF.

Case Report

A 60-year-old man with a 7-year history of recurrent persistent atrial fibrillation (EHRA 3) was referred for repeat catheter ablation. The patient had undergone two prior conventional ablation procedures (PVI) and a total of four electrical cardioversions. He was never in stable
sinus rhythm for a significant time period (despite antiarrhythmic drugs). First PVI was performed 3 years after the first diagnosis of AF, using the pulmonary vein ablation catheter (PVAC). Despite ongoing antiarrhythmic therapy with flecainide, the patient experienced recurrent episodes of paroxysmal AF and finally returned back to persistent AF. Therefore, re-PVI using 3D-guided point by point irrigated radiofrequency (RF) ablation with re-isolation of the right inferior PV (RIPV), right superior PV (RSPV) and left superior PV (LSPV) was performed 2 years after the first PVI. Due to recurrence of persistent AF, 2 months later the patient underwent another electrical cardioversion, and dronedarone was initiated instead of flecainide. During the following 2 years the patient was in stable sinus rhythm (despite ongoing antiarrhythmic drugs). First PVI was performed 3 years after the first diagnosis of AF, using the pulmonary vein ablation catheter (PVAC). Despite ongoing antiarrhythmic therapy with flecainide, the patient experienced recurrent episodes of paroxysmal AF again. CHA2DS2-VASc-Score was 0. Computed tomography (CT) imaging revealed the left atrium was moderately enlarged (51 mm) with an unremarkable PV anatomy. Ejection fraction was found to be slightly reduced by echocardiography (50%). We did not note any signs of reverse remodelling of the left atrium (LA) from the time of initial diagnosis of AF. The patient had no relevant comorbidities.

Anti-arrhythmic medication (dronedarone) was discontinued 4 months prior to ablation. As illustrated in Figure 1, a direct-contact 64-electrode basket catheter (FIRMap, Abbott, Menlo Park, CA) was placed successively in each atrium to record unipolar electrograms. A 50 mm basket catheter was selected according to the LA-diameter (transseptal puncture site to LA-ridge) measured by transesophageal echocardiography (TEE). Basket fit was very good with uniform spline spacing and complete coverage in the left atrium, as shown in figure 2. The right atrium was quite elongated in the craniocaudal direction, so we mapped in different basket positions. Electrograms were filtered at 0.05–500 Hz and exported for analysis by the RhythmView software (Abbott, Menlo Park, CA). The RhythmView FIRM mapping software utilizes previously described computational approaches to generate activation trails for identifying AF rotors within the atria. AF propagation maps from contact recordings were projected onto 2D grids referenced to atrial anatomy on electroanatomic shells, which were created using NavX (St. Jude Medical, Minneapolis, MN) prior to FIRM mapping. RF ablation was performed using an irrigated 4 mm catheter (Therapy Cool Flex, St. Jude Medical, Minneapolis, MN) by applying lesions until elimination or significant reduction of local electrogram amplitude around the rotor core. RF energy was delivered at 30 W with a target temperature of 45°C, and depending on the localization of ablation, the energy was reduced to 25 W (e.g. posterior wall of the left atrium). Rotor mapping was repeated to confirm rotor elimination. All ablated rotors were identified by the Rotational Activity Profiling (RAP) feature of the RhythmView software. In addition, there was further smaller rotational activity identified by RAP in both atria, judged false positive upon visual inspection by the operator and therefore not considered an appropriate ablation target.

One rotor was detected in the right atrium (lateral superior), which was successfully ablated (figure 2). We observed a slight movement of the right atrial (RA) rotor after the initial ablation at this location as demonstrated in figure 3 (epoch 1: splines DEF, electrode 34; epoch 2: splines EF, electrode 23), with complete elimination after additional ablation. It is worth noting that no additional rotors were found after repositioning the basket in the RA. Three more rotors were identified and ablated in the left atrium (posterior wall), shown in figure 2. However, despite complete rotor elimination, atrial fibrillation persisted, but with significant cycle length prolongation from 180 ms at the beginning to 219 ms at the end of rotor ablation (from 180 to 192 ms after RA rotor ablation and finally to 219 ms after LA rotor ablation). Electrical cardioversion was performed to restore sinus rhythm and the RIPV was diagnosed to have reconnected to the atrium. Next, the right inferior PV was re-isolated. The other PVS, which had already been checked prior to rotor ablation, were found to be still completely isolated after the former ablation procedures.

Finally voltage mapping of the left atrium was performed in sinus rhythm and revealed no low voltage area (< 0.5 mV local bipolar electrogram amplitude) beside PVI and ablated rotor zones. Total procedure time was 195 min, time from venous puncture to the end of FIRM 135 min and total RF ablation time was 1986 s. Total rotor RF ablation time was 1443 s. Total fluoroscopy time was 21 min. No complications occurred.

The patient is completely off specific antiarrhythmic drugs since this ablation (only low dose betablocker, Nebivolol 2.5 mg/d). Interestingly, 11 weeks after the FIRM-guided procedure, he had a recurrence of atrial fibrillation as noted by resting ECG. He converted spontaneously back to sinus rhythm without any intervention 2 weeks later however. Since this time the patient has been in stable sinus rhythm (23 month follow-up period, documented by 7d Holter after 6 and 12 months, 24h Holter after 18 months, multiple resting ECGs in between) and was free of symptoms.

**Figure 1**: FIRM-guided rotor ablation procedural workflow. The procedural steps for FIRM-guided rotor ablation.
Discussion

This case highlights the need to effectively address the specific AF mechanism in patients with recurrent persistent atrial fibrillation. Despite the fact that the vast majority of literature, as well as the latest ESC guidelines, emphasize the need for complete PVI as a first approach for paroxysmal and persistent AF patients, there is a large and growing patient population with recurrent AF that could benefit from an ablation approach that goes beyond the PVs. Although there are contradicting data available on the effectiveness of FIRM-guided rotor ablation, multiple independent investigators have reported favorable results using this technology in difficult patient populations.

An observation of particular interest in this case is the spontaneous conversion to stable sinus rhythm after a brief recurrence of AF 11 weeks after the procedure. This may be explained mechanistically by reverse remodeling.

Figure 2: Atrial rotor locations. Figure 2A: NavX map showing a rotor in the right atrium and indication of basket fit in this elongated atrium. Note that two ablation areas are indicated, which in fact represent the same rotor.

Figure 2B: NavX map showing the ablation areas indicating the rotor locations in the left atrium, and the deployment of the basket catheter in the left atrium (below).
Albeit controversial, reverse remodeling of the atria does in fact appear to occur after the restoration of sinus rhythm, and may result in a progressive lowering of AF burden.\(^\text{16,17}\) This is consistent with our observation that FIRM-guided rotor ablation appears to be an advantageous alternative. There is one main limitation of this case report. It is possible that re-isolation of the RIPV alone can explain the result. However, the patient had never been in sinus rhythm for more than a few weeks after both prior PVI. It is worth noting that enrollment was recently initiated for a multi-center randomized controlled trial to definitively determine if FIRM-guided rotor ablation in addition to PVI improves outcomes for patients with previously failed conventional ablation (ClinicalTrials.gov identifier: NCT02799043).

References


