A combination of pulmonary vein isolation (PV), electrogram-based ablation, and linear lesions have been demonstrated to result in medium-term freedom from atrial fibrillation (AF) in the majority of patients with persistent AF in several studies. Such an extensive ablation is associated with a high incidence of postablation atrial tachycardia (AT), which is often complex and multiple. Deductive mapping strategy,1,2 which consists of activation mapping and entrainment mapping, can identify the mechanism and/or source of the postablation AT rapidly and accurately. However, careful mapping and close observation to identify subtle changes between the ATs are necessary. Postspacing interval (PPI) mapping is a useful technique, with some limitation for focal AT.3–5

We present a case that demonstrated multiple postablation ATs requiring careful mapping for identifying each of them. It also demonstrated the utility of PPI mapping in the precise diagnosis of the sources of focal ATs.

Case Reports

A 47-year-old man with an 8-year history of paroxysmal lone AF, not controlled with amiodarone, was admitted to our institution with persistent AT for his third catheter ablation procedure. At the first procedure, 7 years ago, PV isolation was performed. Six months ago, reisolation of PVs, electrogram-based ablation, and linear ablation of left atrial (LA) roof and left mitral isthmus for inducible AT were performed, which completely blocked both lines. The AT cycle length (ATCL) was 275 ms during the start of the third procedure. A steerable decapolar catheter was inserted into the coronary sinus (CS), and an externally irrigated ablation catheter (Thermocool, Biosense Webster) was advanced into the LA via a transseptal puncture. Oral anticoagulation therapy was discontinued 3 days before the procedure. After transseptal puncture, a bolus of 50 IU/kg of heparin was administered. No PV reconnection was observed. Mapping revealed the mechanism of clinical AT as a double-loop reentry (simultaneous presence of the perimital AT and the roof-dependent AT), based on the finding that the activation sequence was compatible with both ATs and ΔPPI-ATCL was <20 ms at the LA roof, anterior, and posterior LA besides at the mitral annulus. After 74 seconds of radiofrequency application on the LA roof, clinical AT got converted to perimital AT with CL of 290 ms (Figure 1). The morphology of the P wave and the activation sequence of the CS electrograms did not change (Figure 1, red arrows). After endocardial and epicardial radiofrequency application on the left mitral isthmus the second AT got converted to the third AT (Figure 2). However, there was no change in the ATCL or the activation sequence of the CS electrograms. The conversion was marked by a change in the morphology of P wave (Figure 2B). The third AT was diagnosed as focal AT originating from the high LA septum, and 9 seconds of radiofrequency application at this site restored sinus rhythm (Figure 3). PPI mapping was used to localize this focus, and ΔPPI-ATCL was longer at left middle septum, fossa ovalis, right septum, and CS ostium than left high septum. After the confirmation of bidirectional block across the left mitral isthmus, the LA roof, and the cavotricuspid isthmus lines using differential pacing techniques, fourth AT was easily induced by proximal CS burst pacing at 250 ms (Figure 4A and 4B). It was diagnosed as focal AT originating from the posterolateral LA below and behind the left mitral isthmus line of block. It was eliminated by 15 seconds of radiofrequency application, and termination was marked by the activation of bipole CS1–2 in absence of the activation of the remainder of the CS bipoles (Figure 4C). PPI mapping was used to localize this focus, and ΔPPI-ATCL was 0 at this site. No tachycardia was inducible on further testing. Total fluoroscopy, radiofrequency, and procedural times were 30, 29, and 80 minutes, respectively.

Discussion

Deductive mapping strategy1,2 can identify the postablation ATs rapidly and accurately; however, careful observation is necessary to ensure precision of the mapping procedure. This case demonstrates 4 different ATs, including 2 macroreentrant and 2 focal ATs, in a patient who was previously subjected to extensive LA ablation procedure. First and second ATs were macroreentrant ATs, which were diagnosed with activation and entrainment mapping. Conversion from the first AT to the second one was identified just by the prolongation in ATCL. Possible explanation of this change is that because CS activation was mostly determined by the perimital component of the first AT, it did not change during its conversion to second AT, which...
was an isolated perimital AT with longer ATCL than the previous AT. P-wave morphology did not change. Theoretically, after extensive LA ablation, the relative contribution of the LA toward the composition of surface P wave should be smaller compared with that of the right atrium (RA). In other words, RA activation should be predominantly responsible for determining the morphology of surface P wave. This observation was confirmed later during sinus rhythm in this case. Conversion of first AT to the second one did not result in any change in the activation pattern of RA, the passive chamber, which could explain the absence of alteration in the morphology of P wave between the 2 ATs. The third AT was identified as a focal AT. The interesting part is that the CS activation sequence and the ATCL did not change when macroreentrant AT was converted to focal AT and the conversion was identified only by the subtle change in the P-wave morphology. Because the focus lay on the left side of the high septum and the mitral isthmus line was completely blocked during ablation of the second AT, it seemed that any change in the activation sequence of the CS was forbidden. Although the conversion of second AT to the third one involved a subtle change, careful observation of the P-wave morphology helped to clinch the diagnosis. The fourth AT could be quickly identified as focal AT because bidirectional block across all the lines was established previously, which obviated the possibility of macroreentrant ATs. Because the CS activation pattern during the fourth AT was eccentric with the earliest activation of bipole CS 5 to 6, mapping around it confirmed low posterolateral LA as the source of this AT. In this case, to identify the focus, not only activation mapping but also PPI mapping was very useful. We performed PPI mapping several times from both sides of the atrial septum to precisely spot the third AT. The interesting part of the fourth AT was its mode of termination. The last tachycardia beat resulted in activation of a small area of the LA around the proximal electrode pair of the ablation catheter and the bipole CS1–2. Tachycardia terminated without activation of any of the remaining CS bipoles and inscription of P wave on the surface ECG. The possible explanation for the observed phenomenon could be that the radiofrequency application closed the exit of impulse from the focus, which was surrounded by the lesions from the previous ablation. The last beat of the tachycardia did not activate the proximal CS, which was along the route of impulse traveling to the RA. Because the activation of RA was mainly responsible for the inscription of the P wave on the surface ECG, it is possible that because the tachycardia terminated without the activation of RA, there was an absence of P wave (Figure 4C and 4D). The relation between the P wave and the RA activation was supported by the findings during sinus rhythm. Most of the sinus P wave coincided with the activation of the RA, and activation of the CS was delayed, suggestive of huge inter-
atrial conduction delay caused by previously undertaken extensive ablation (Figure 3D).

Entrainment pacing can identify sites within a macroreentrant circuit, where the PPI equals the tachycardia cycle length. In contrast to a macroreentrant circuit, constant and progressive fusion or concealed entrainment cannot be used to diagnose a focal tachycardia. Recently, Colombowala et al. demonstrated that centrifugal tachycardias exhibited a large variability in the PPI regardless of the mechanism (microreentry versus no reentry) when compared with the macroreentrant tachycardias. On the other hand, Mohamed et al. proved that the \( \Delta \)PPI-ATCL after atrial overdrive pacing is related to the distance from the focal source regardless of the mechanism of tachycardia and that it was useful to localize the focus in conjunction with the activation mapping. In this case, PPI mapping was useful to identify and diagnose not only the macroreentrant ATs but also the focal ATs.

Previous reports demonstrated that the presence of isoelectric interval between the tachycardia P waves may be useful in making a diagnosis of the focal mechanism of tachycardia. In other words, macroreentrant circuits lack an isoelectric interval, and AT with a nonreentrant mechanism presents with discrete P waves separated by an isoelectric interval on the ECG. However, this holds true in the patients without extensive atrial tissue ablation. We believe that large conduction delay caused by extensive ablation could make the focal AT lose an isoelectric interval on the ECG as observed in this case. On the contrary, extensive atrial ablation is also responsible for very slow conduction spanning over a large part of tachycardia cycle length but occurring in a small part of the macroreentrant circuit. Such a long delay can inscribe an isoelectric interval in between the macroreentrant-tachycardia P waves on ECG, which is sometimes not sensitive enough to record slow activation occurring in a small area of the atrium.

Although extensive atrial ablation for persistent AF has shown a good clinical outcome in the medium term, usually multiple procedures are required for treatment of recurrent ATs, which potentially could increase the risk of procedure complications, such as cerebral embolism. Furthermore, the clinical significance of ATs induced in the electrophysiology laboratory is not fully understood. In fact, a previous report showed that some part of spontaneous ATs and ATs induced in the electrophysiology laboratory in the context of AF ablation resolve spontaneously. Further studies are needed to clarify the significance of these ATs and the long-term clinical outcome after extensive atrial ablation.
This case highlights the importance of careful observation during radiofrequency application for the ablation of ATs arising in the context of AF ablation.

Disclosures

None.

References


Key Words: atrial flutter ■ atrial fibrillation ■ catheter ablation
Multiple Atrial Tachycardias After Atrial Fibrillation Ablation: The Importance of Careful Mapping and Observation
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