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CASE REPORT

ADVANCED

CLINICAL CASE

Noncontact Charge Density Mapping–Guided Ablation of Persistent Atrial Fibrillation With a Multiple Trigger-Based Mechanism

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ABSTRACT

We present a case of radiofrequency catheter ablation of persistent atrial fibrillation (AF) with a trigger-based mechanism, guided by novel noncontact charge density mapping, which resulted in the simultaneous achievement of the termination of AF and complete elimination of multiple triggers that induced repeated recurrences of AF immediately after cardioversion. (**Level of Difficulty: Advanced.**) (J Am Coll Cardiol Case Rep 2023;21:101957) © 2023 The Authors. Published by Elsevier on behalf of the American College of Cardiology Foundation. This is an open access article under the CC BY-NC-ND license (http://creativecommons.org/licenses/by-nc-nd/4.0/).

HISTORY OF PRESENTATION

A 79-year-old man had severe recurrent palpitations due to persistent atrial fibrillation (AF) with a heart rate of >100 beats/min every week.

PAST MEDICAL HISTORY

He had a history of a pulmonary vein (PV) isolation and cavotricuspid isthmus linear ablation of AF at the age of 70 years.

MANAGEMENT

He had sinus rhythm on admission but persistent AF at the beginning of the second catheter ablation pro-

LEARNING OBJECTIVES

- To understand that it is sometimes difficult to completely eliminate all non-PV triggers, which induce an IRAF after cardioversion, in persistent AF by catheter ablation guided by conventional contact mapping systems.
- To understand the unique features of a novel 3-dimensional CDM system: noncontact, single-beat, and global mapping.
- To understand the usefulness of noncontact CDM for completely eliminating multiple IRAF triggers and terminating AF during catheter ablation of multiple trigger-based persistent AF.

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ABBREVIATIONS AND ACRONYMS

AF = atrial fibrillation

CDM = charge density mapping

IRAF = immediate recurrence of atrial fibrillation

LA = left atrium

LAPW = left atrial posterior wall

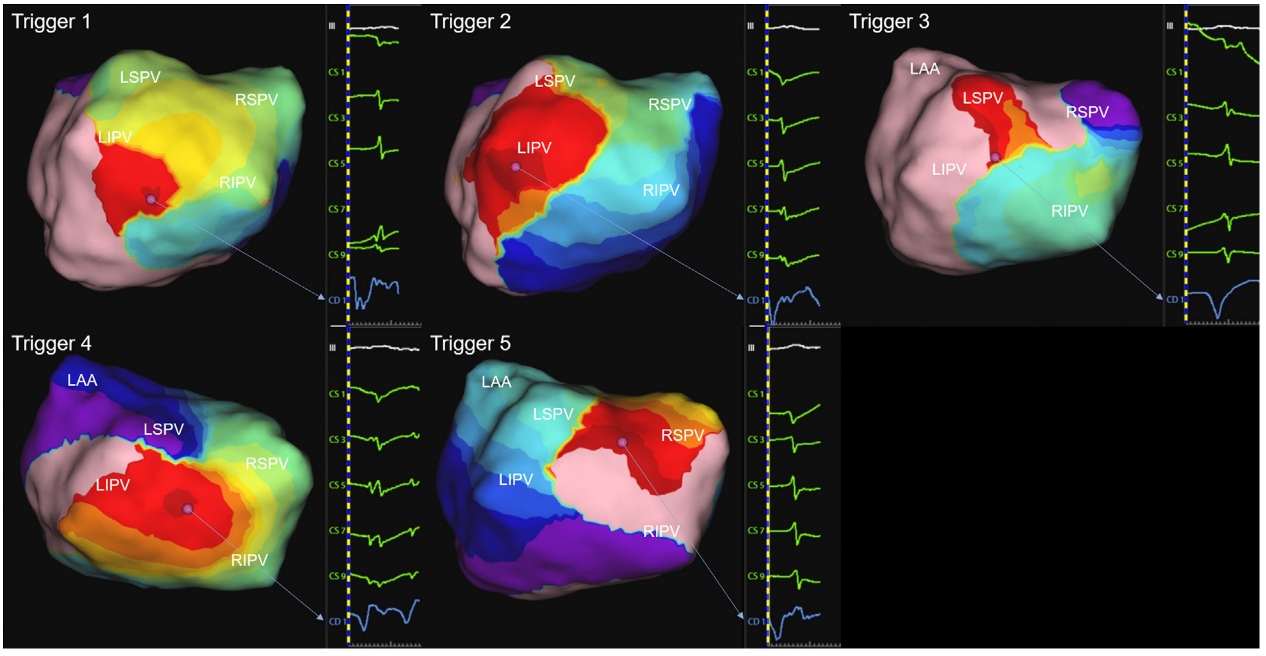
LIA = localized irregular activation

LRA = localized rotational activation

PV = pulmonary vein

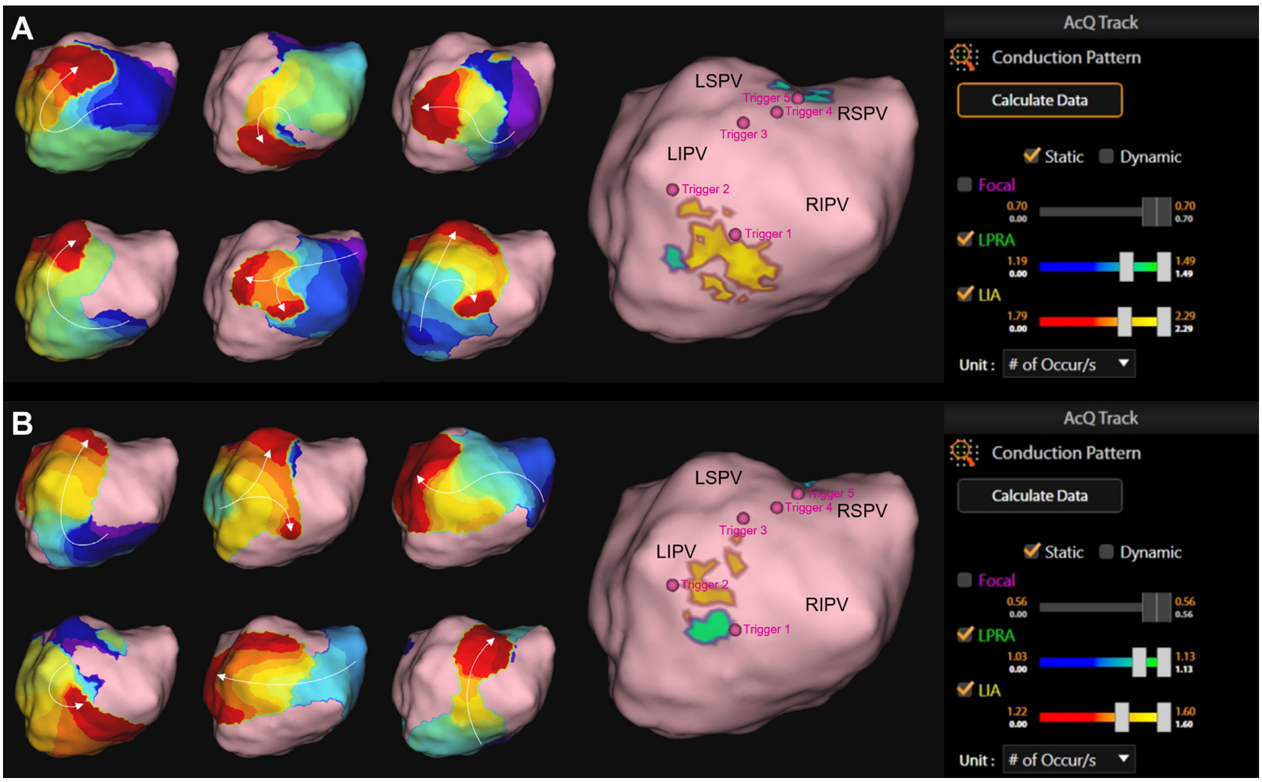
cedure guided by a charge density mapping (CDM) system (AcQMap, Acutus Medical). Two transseptal sheaths were advanced into the left atrium (LA) via one transseptal puncture site. A 10-F, 48-pole noncontact CDM catheter (AcQMap mapping catheter, Acutus Medical) was inserted into one sheath and a decapolar circular mapping catheter (Libero, Japan Lifeline Co) or contact force-sensing irrigated ablation catheter (ThermoCool Smarttouch SF, Biosense Webster) into the other. An immediate recurrence of atrial fibrillation (IRAF) after restoration of sinus rhythm by external electrical cardioversion repeatedly occurred. After creating the ultrasound-based LA anatomy, noncontact CDM identified multiple non-PV triggers that repeatedly induced an IRAF and originated from 2, 1, and 2 foci on the inferior, middle, and superior portions of the left atrial posterior wall (LAPW), respectively (**Figure 1**, Supplemental Figures 1 and 2, Video 1). Further, noncontact CDM was performed during the AF for 30 seconds, and 2 10-second mapping segments were created. The AcQTrack algorithm is capable of presenting three types of abnormal conduction patterns during AF: focal activation is characterized by a centrifugal activation counter from a single point, localized rotational activation (LRA) is characterized by a smooth rotational activation of >270 degrees, and localized irregular activation (LIA) is characterized by a change in the wavefront direction of >90 degrees and speed, breakthrough conduction through a confined zone, and wavefront pivoting.[1,2] Those mapping segments exhibited LRA and LIA but no focal activation on the LAPW according to the AcQTrack algorithm (**Figure 2**, Video 2). The IRAF foci were adjacent to areas with abnormal conduction patterns during AF, and the IRAF foci and those areas were targeted for ablation. Each application of radiofrequency energy was delivered with a power output and duration of 40 W to 50 W and <30 seconds (40 W and <15 seconds near the esophagus). Catheter navigation was performed on the AcQMap system based on the impedance-based technology,

FIGURE 1 **Noncontact CDM Using a Single Position Mode During IRAF Triggers**



The IRAF triggers originated from the inferior (triggers 1 and 2), middle (trigger 3), and superior LAPW (triggers 4 and 5). The absence of mechanical contact between the CDM catheter and LA endocardium was monitored on the AcQMap system during the mapping. The colors on the maps represent the propagation histories of the activation wavefront. **Red** indicates the earliest location of the activation wavefront. **Orange to purple** indicate the later locations. The pink tags and CD1 represent the breakout sites of the IRAF triggers and local charge density signal at the breakout sites, which exhibit a QS morphology. CD1 = charge density signal; CDM = charge density mapping; IRAF = immediate recurrence atrial fibrillation; LA = left atrial; LAA = left atrial appendage; LAPW = left atrial posterior wall; LIPV = left inferior pulmonary vein; LSPV = left superior pulmonary vein; RIPV = right inferior pulmonary vein; RSPV = right superior pulmonary vein.

FIGURE 2 Noncontact CDM Using a Single Position Mode During AF



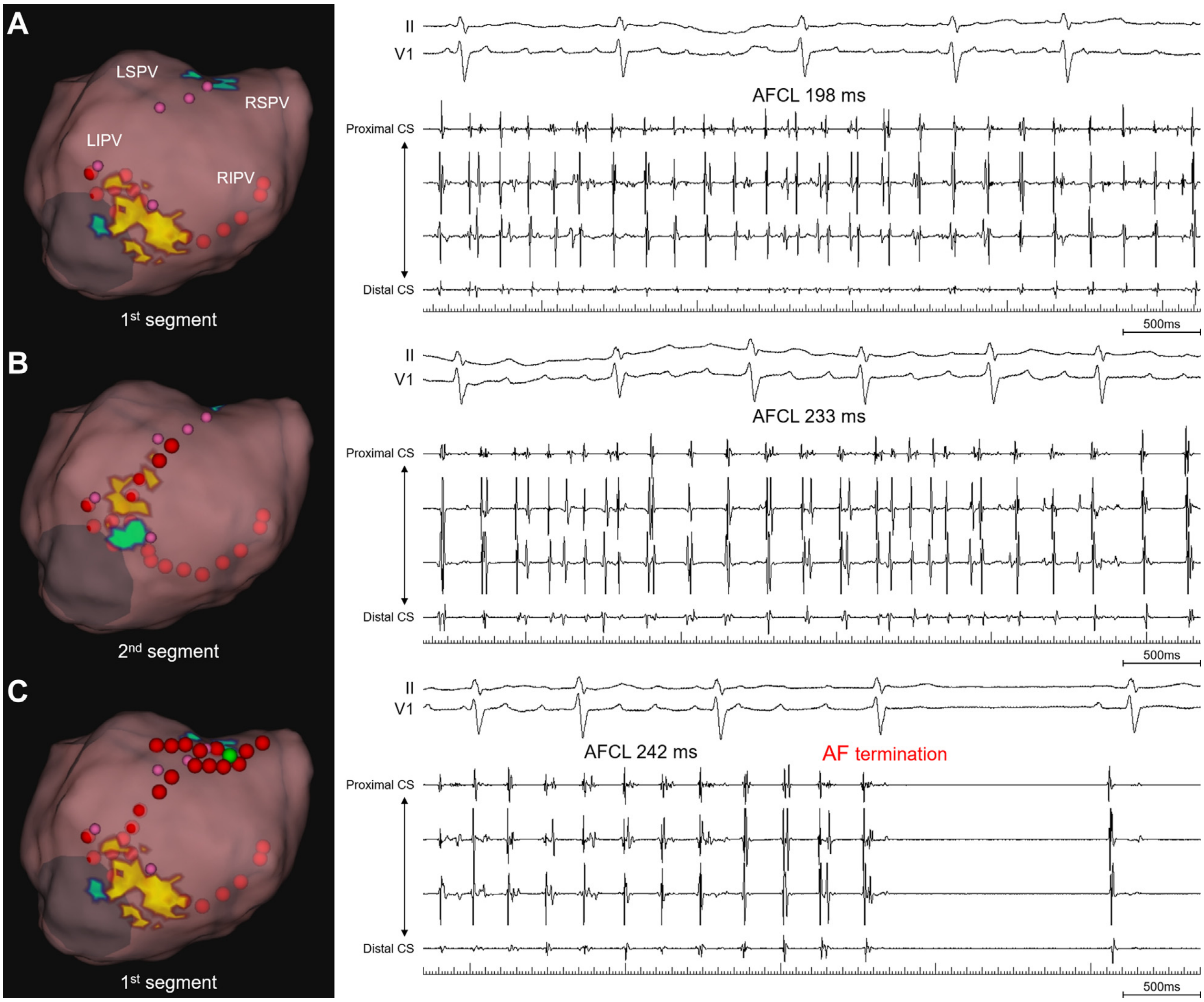
The **(A)** first and **(B)** second 10-second mapping segments exhibited abnormal conduction patterns on the LAPW. The **left panels** represent the propagation histories of the activation wavefront. **Red** indicates the leading edge of the wavefront with the trailing color bands showing earlier locations of the wavefront **(white arrows)**. In the right panels, the AcQTrack analyses show the LRA and LIA on the superior and inferior LAPW in the first segment and those on the middle and inferior LAPW in the second segment. The area with an LRPA number of 1.19-1.49 per second in the first segment and 1.03-1.13 per second in the second segment is colored in green, and that with an LIA number of 1.79-2.29 per second in the first segment and1.22-1.60 per second in the second segment is colored in **yellow**. AF = atrial fibrillation; LPRA, localized partial rotational activation; LIA, localized irregular activation; LRA = localized rotational activation; other abbreviations as in Figure 1.

and contact force information was monitored on the CARTO 3 system (Biosense Webster). The esophageal temperature was monitored using an esophageal temperature probe (SensiTherm, Abbott), and an esophageal temperature limit of 41 °C was defined to interrupt the radiofrequency energy deliveries. Radiofrequency applications were performed in the order of the inferior, middle, and superior LAPW. The AF cycle length prolonged after ablation on the inferior LAPW, and the AF transformed into an atypical atrial flutter and terminated after ablation on the middle and superior LAPW (Figure 3). Thereafter, no IRAF spontaneously occurred. An additional radiofrequency application near the esophagus completed the LAPW isolation (Video 3). All PVs were confirmed to be electrically isolated. No IRAF triggers could be further induced by any atrial burst pacing or administration of a bolus infusion of 40 mg of adenosine triphosphate and 10 μg of isoproterenol followed by a continuous 4 μg/min infusion, which increased his heart rate up to 160 beats/min.

DISCUSSION

Non-PV trigger foci of AF are widely distributed over the atria and are sometimes difficult to identify by conventional contact mapping, especially if there are multiple foci.[3-5] The novel CDM system has a great advantage in mapping multiple triggers associated with an IRAF because of the unique features of noncontact, single beat, and global mapping.[6] Further, that system is also capable of mapping abnormal conduction patterns during AF, which may be related to the maintenance of AF.[7,8] Shi et al[8] reported that a PV isolation plus ablation targeting CDM-based abnormal conduction patterns during AF

FIGURE 3 Radiofrequency Ablation Sites on the Ultrasound-Based LA Anatomy



(A) Radiofrequency applications on the inferior LAPW prolonged the AF cycle length from 198 to 233 ms, which was measured in the coronary sinus by averaging 10 cycles **(right panels)**. Further, radiofrequency applications on the **(B)** middle and **(C)** superior LAPW terminated the AF. The **pink, red, and green tags** represent the sites with the IRAF triggers, radiofrequency ablation sites, and AF termination site, respectively. The **green and yellow areas** represent the areas with LRA and LIA using the AcQTrack algorithm, respectively. AFCL = AF cycle length; other abbreviations as in Figures 1 and 2.

had a higher success rate of AF termination and better clinical outcome as compared to an empirical PV and LAPW isolation. The CDM during the AF in the present case exhibited abnormal conduction patterns on the LAPW, and all IRAF triggers originated near areas with those abnormal conduction patterns. Thus, we set the ablation lesions for isolating the LAPW to encircle the areas with the IRAF triggers and abnormal conduction patterns. As a result, both the complete elimination of the IRAF triggers and termination of AF could be simultaneously achieved. The radiofrequency applications on the middle LAPW in addition to the LAPW isolation may not have been necessary but was performed because the LAPW isolation area was relatively large and there was concern about LAPW reconnections.

FOLLOW-UP

The patient had neither palpitations nor atrial tachyarrhythmia recurrences by the 3-month follow-up, but further follow-up will be needed to validate the efficacy of this ablation strategy.

CONCLUSIONS

Noncontact global CDM can be useful for mapping and ablating multiple IRAF triggers and abnormal conduction patterns during AF and may provide an individualized ablation strategy for persistent AF with a multiple trigger-based mechanism.

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The authors have reported that they have no relationships relevant to the contents of this paper to disclose.

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KEY WORDS atrial fibrillation, charge density, conduction pattern, noncontact mapping, persistent atrial fibrillation, trigger

APPENDIX For supplemental figures and videos, please see the online version of this paper.