A novel mapping technique to detect non–pulmonary vein triggers: A case report of self-reference mapping technique

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Introduction
Catheter ablation is an effective therapeutic strategy for atrial fibrillation (AF). Pulmonary vein (PV) isolation is the cornerstone of catheter ablation for AF. After all PVs were isolated, ablation of non-PV triggers should be attempted. Successful elimination of all the possible AF triggers is considered a better outcome.1,2 Mapping of non-PV triggers is usually performed using 3-dimensional anatomic mapping; however, precise mapping of non-PV triggers is sometimes difficult. The electrogram obtained using the reference catheter is not suitable to use as the reference, because of poor stability of the catheter, ventricular electrogram overlap, or dull potential after cardioversion. A new technique, self-reference mapping, does not require other reference catheters, because it uses the previous earliest activation site recorded with the PentaRay NAV (PEN) catheter (Biosense Webster Inc., Diamond Bar, CA) as the reference (Figure 1).

Case report
A 75-year-old man with a 2-month history of persistent AF and transient ischemic attack was referred to our institution for catheter ablation. Catheter ablation was performed using an open-irrigated contact-force catheter (ThermoCool SmartTouch SF, Biosense Webster) with an electroanatomic mapping system (CARTO 3, Biosense Webster). After circumferential bilateral PV isolation and superior vena cava isolation, continuous isoproterenol infusion (2 µg/min) and adenosine triphosphate (ATP) rapid injection (30 mg) were performed to provoke non-PV trigger.3 AF was induced by ATP administration, and spontaneous AF initiation was reproducibly observed by the postcardioversion AF trigger.

Self-reference mapping was performed as follows. As the first step, PEN was located at the low left atrial septum side because the earliest activation site of the non-PV trigger except PEN was the proximal coronary sinus. The earliest activation site of the first non-PV trigger was PEN 17-18. The red tag was placed at PEN 17-18 (Figure 2A). The ablation catheter was located in the right atrium at the opposite site of PEN (Figure 2A). Activation of the ablation catheter was later than that of PEN, and following mapping iterations were performed in the left atrium.

PEN was moved to a higher position including the previous red tag. The earliest activation sites of the next non-PV trigger were PEN 13-14 and PEN 15-16. The yellow tag was placed at PEN 15-16, and another tag was placed at PEN 13-14 (Figure 2B). PEN was moved to the anterior position. The earliest activation site of the next non-PV trigger was PEN 15-16. The yellow tag was placed at PEN 15-16. The earliest tags obtained by inner electrodes of PEN were concentrated in a small area. The area was supposed to be the origin of the non-PV trigger (Figure 2C). PEN was moved more anterior, including the previous earliest yellow tag to confirm the accuracy of the map. The earliest activation site of the next non-PV trigger was PEN 9-10, which was the same place as the previous earliest activation site (Figure 2D). During self-reference mapping, the operator has to pay close attention to the intracardiac activation sequence of beat triggering AF as well as the coupling interval in order to distinguish a true spontaneous trigger from catheter-induced ectopy.

Ablation was performed during AF to cover the yellow tag sites maintaining contact force at least 10 g (25 W, 25 seconds at each point). The end point of ablation was noninducibility of AF after cardioversion. After 1 series of ablation (7 points), AF was never induced by ATP administration (ATP administrations were performed 7 times and AF was never induced) during continuous isoproterenol infusion.

Discussion
The main goal of catheter ablation for AF is elimination of all the possible triggers from both PV and non-PV, which typically arise from a discrete anatomical structure.4 Because a non-PV trigger conducts centrifugally, the
earliest site should be distinguished from other later activated sites. This map, the map to identify the earliest site, size is considered to be within the range of the PEN catheter size. In this article, we proposed a new self-reference mapping technique to detect non-PV triggers.

Our technique is similar to the previously reported vector mapping technique, which is performed to characterize atrial tachycardia. Vector mapping is performed to identify the earliest activation site comparing PentaRay NAV catheter electrogram with the P wave and fixed catheter within coronary sinus. The concept of searching the core of the centrifugal activation pattern by focal atrial tachycardia or non-PV triggers is the same. Vector mapping is performed with regard to localized reentry and focal atrial tachycardia. Our technique is specialized for non-PV trigger mapping and does not require the reference catheter. Moreover, a recently developed 3-dimensional anatomic mapping technique made it possible to obtain a tag by a multielectrode catheter. These 2 advantages led us to make a precise high-resolution map in a small area easily.

There are some limitations of this mapping method. This mapping method needs reproducible AF initiation from the same site. When multiple triggers were observed, we tried to map 1 by 1, assessing the intracardiac activation sequence. We do not have experience using this method in cases post excessive atrial ablation, such as CFAE or step wise substrate ablation, because we do not perform these kinds of ablation methods at our institution.

In these cases, conduction of the atrial myocardium might be significantly affected by excessive ablation and the

| KEY TEACHING POINTS |
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| • Self-reference mapping with the PentaRay NAV catheter is useful to detect non-pulmonary vein triggers. |
| • This new mapping technique uses the previous earliest electrode site as the reference and does not require other reference catheters. |
| • The earliest site should be distinguished from other later activated sites. This map, the map to identify the earliest site, size is considered to be within the range of the PentaRay catheter size. |

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![Diagram A](image1)

A: A non-pulmonary vein trigger is considered to conduct centrifugally. The earliest activation site of the PentaRay catheter, which is located far from the trigger, should be one of the outer electrodes (1-2, 5-6, 9-10, 13-14, 17-18).

B: The PentaRay catheter is moved to the earlier activation site and placed including the previous earliest site, which is used as the reference for the next trigger mapping method.

C: After several mapping iterations, one of the inner electrodes (3-4, 7-8, 11-12, 15-16, 19-20) of the PentaRay catheter can record the earliest activation site. It means that activation of all the outer electrodes is late.

D: When the earliest activation tags are concentrated in a small area, the area is the origin of the trigger.

"Figure 1" Theoretical illustration of self-reference mapping. A: A non-pulmonary vein trigger is considered to conduct centrifugally. The earliest activation site of the PentaRay catheter, which is located far from the trigger, should be one of the outer electrodes (1-2, 5-6, 9-10, 13-14, 17-18). B: The PentaRay catheter is moved to the earlier activation site and placed including the previous earliest site, which is used as the reference for the next trigger mapping method. C: After several mapping iterations, one of the inner electrodes (3-4, 7-8, 11-12, 15-16, 19-20) of the PentaRay catheter can record the earliest activation site. It means that activation of all the outer electrodes is late. D: When the earliest activation tags are concentrated in a small area, the area is the origin of the trigger.
impaired electrogram postablation might be not suitable for assessing the conduction pattern. A study is needed to elucidate the accuracy, success rate, and safety of the self-reference mapping method.

Conclusion
This case demonstrated the usefulness of self-reference mapping to detect a non-PV trigger induced by isoproterenol and adenosine triphosphate.

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