Persistent atrial fibrillation originating from the prominent Eustachian ridge: Precise identification of non-pulmonary vein foci using the Advisor™ HD Grid catheter

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Abstract

We describe a rare case of persistent atrial fibrillation originating from the prominent Eustachian ridge. A detailed mapping using the Advisor™ HD Grid catheter enabled precise identification of the non-pulmonary vein foci at the prominent Eustachian ridge. A local interatrial conduction block was observed during a single ectopy or short run. Highly localized radiofrequency ablation could completely cure persistent atrial fibrillation.

Keywords: atrial fibrillation, non-pulmonary vein, Eustachian ridge, Advisor™ HD Grid catheter, interatrial conduction block, inferior vena cava.

Introduction

Atrial fibrillation (AF) mostly originates from the pulmonary vein (PV). As a result, 70−90% of AF patients can be cured with extensive PV isolation. However, the remaining 10–30% of these patients have non-PV foci, [1-3] the precise identification of which is often difficult. In patients with the spontaneous cessation of AF, it may be relatively easy to map the non-PV foci. However, non-PV foci trigger mapping is difficult if AF does not spontaneously terminate, and electrical cardioversion is needed to terminate AF. We wanted to precisely determine the origin of non-PV foci with as few electrical cardioversions as possible. However, with conventional multipolar catheters alone, it is difficult to accurately identify the precise origin of the tachycardia. This case report demonstrated that the Advisor™ HD Grid catheter could be an extremely useful tool for pinpointing the origin of non-PV foci at the prominent Eustachian ridge. Further, local interatrial conduction block was observed during single ectopy and short run.

Case presentation

A 50-year-old man was referred for catheter ablation due to persistent AF. Echocardiography showed a normal ejection fraction and a left atrial diameter of 44 mm. After all pulmonary veins and left atrial posterior wall isolation were performed during

AF, electrical cardioversion converted AF to sinus rhythm. However, after a few seconds, AF recurred. Despite repeated electrical cardioversions, AF was continuously reinitiated soon. The intracardiac excitation sequence during the first beat of non-PV AF was always the same, and the coronary sinus conduction was from proximal to distal, and the most proximal site of the Halo catheter, which was located at the low right atrial septum, was the earliest activation site. Then, we inserted the Advisor™ HD Grid catheter into the low right atrial septum and mapped the earliest atrial activation site of the non-PV foci. The Advisor™ HD Grid catheter showed the earliest activation site in the anterior direction of the right atrium. A CT scan image recorded before the procedure revealed a prominent Eustachian ridge (Figure 1). Therefore, we moved and fixed the Advisor™ HD Grid catheter toward this prominent Eustachian ridge. After cardioversion, single atrial ectopy with a short interval of 170 ms appeared, however, this excitement did not occur in the surrounding right atrial muscle (Figure 2). Four consecutive ectopic beats were conducted in the right atrium and the coronary sinus in a 2:1 fashion, suggesting the presence of an interatrial conduction block. A few seconds later, local ectopic beats with rapid firing of a mean cycle length of 120 ms triggered sustained AF again. Furthermore, it was demonstrated that the earliest activation site of the first ectopic beat was the C-spline of the Advisor™ HD Grid catheter, neither the A-spline nor the D-spline. This intracardiac

finding implied that the exact non-PV foci were situated within this Advisor™ HD Grid catheter facing the prominent Eustachian ridge. Then, we tagged the position of electrodes 2 and 3 of the C-spline and removed the Advisor™ HD grid catheter (Figure 3). We subsequently placed the radiofrequency ablation catheter to the tagged sites. After a couple of radiofrequency applications at these sites, electrical cardioversion was performed. Thereafter, AF never recurred. The patient was free from AF without any antiarrhythmic drugs during 18 months of follow-up.

Discussion

In terms of the distribution of non-PV foci triggering AF, non-PV foci overwhelmingly originate from the superior vena cava (SVC), left atrial posterior wall (LAPW), and left atrium around the PV.[1] The other favorable sites include the vein of Marshall, coronary sinus, atrial septum, mitral annulus, tricuspid annulus, both atrial appendages, and the inferior vena cava (IVC).[2] Non-PV foci originating from the Eustachian ridge are extremely rare. Hayashi et al. reported the distribution of 39 mappable non-PV foci and favorable ablation outcomes of this mappable non-PV AF. 15 and 6 of the 39 non-PV foci originated from the SVC and LAPW, respectively.[3] These non-PV foci are easily curable with SVC and LAPW isolation, and therefore, precise identification is not always

necessary. However, on the other hand, for the other non-PV foci, precise identification of the non-PV foci is necessary, and the key to successful ablation is how to accurately identify these non-PV foci. However, conventional mapping methods have some limitations. In the present study, we used the Advisor™ HD Grid catheter to map the non-PV foci, which makes it easy to monitor vertical and horizontal conduction of excitement arising from non-PV foci due to its structure. A self-reference mapping was performed by tagging the earliest activation site of the Advisor™ HD Grid catheter on a three-dimensional mapping image and then moving the Advisor™ HD Grid catheter upstream of the excitation one after another. Finally, the site where the tagged earliest activation site overlaps the previous tagged site was exactly the precise origin of tachycardia at the non-PV foci triggering AF. A self-reference mapping using the Advisor™ HD Grid catheter could lead to the precise pinpoint of the non-PV foci. Thus, the Advisor™ HD Grid catheter could be an ideal catheter for mapping non-PV foci enabling us to effectively reach the precise origin of tachycardia at the non-PV foci with as few electrical cardioversions as possible. Santangeli et al. reported the distribution of non-PV foci.[4] They reported the combined proportion of crista terminalis and the Eustachian ridge originated AF, and hence, so could not understand the details of how much the Eustachian ridge originated AF was included.[4] The Eustachian ridge is a normal anatomical structure

that separates the orifice of the IVC from the orifice of the coronary sinus. Waki et al. reported that the pectinate muscles were radiated from the crista terminalis in the cavotricuspid isthmus in a parallel fashion, and the Eustachian ridge contained a muscular extension from the crista terminalis in most cases.[5] Cabrera et al. also demonstrated that 8 of 30 (27%) heart specimens had a prominent Eustachian ridge with a thick musculature.[6] A histological study demonstrated the presence of pacemaker cells within the Eustachian ridge, suggesting a potential source of abnormal automaticity causing atrial tachycardia or AF.[7] In this patient, local ectopic beats with interatrial conduction block, similar to PV firing with exit block in patients with PV-originated AF, were observed. The presence of the Eustachian ridge is difficult to determine by conventional right atrial angiography alone; therefore, preoperative contrast-enhanced CT or intracardiac echocardiographic evaluation is very useful. Although some authors reported AF originating from the IVC,[8,9] Igawa et al. reported that IVC extension into the posteroinferior right atrium exists and varies, although this site always lacks myocardium on a detailed anatomical assessment of the IVC and the right atrial junction.[10)] In light of these findings, AF originating from the Eustachian ridge may be misdiagnosed as that originating from the IVC if the anatomy is not thoroughly evaluated with contrast CT or other investigations. Radiofrequency catheter ablation of the Eustachian ridge is easy and

safe. The Advisor™ HD Grid catheter is very useful for detailed mapping to arrive at the precise identification of non-PV AF foci.

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Figure Legends

Figure 1. Three-dimensional CT image. The prominent Eustachian ridge (red arrows) is noted.

Figure 2. Intracardiac electrograms immediately after electrical cardioversion. The Advisor™ HD Grid catheter was situated at the prominent Eustachian ridge. (A) A single atrial ectopic beat was recorded only at the Advisor™ HD Grid catheter. However, this excitement was not conducted to the surrounding right atrium and the coronary sinus, suggesting an interatrial conduction block. Then, four consecutive ectopic beats were conducted in the surrounding right atrium and the coronary sinus in a 2:1 fashion. (B) A few seconds later, atrial ectopic beats originating from the Eustachian ridge triggered AF. The earliest atrial activation was recorded at the C-spline of the Advisor™ HD Grid catheter (not A- or D-spline), suggesting the precise identification of these non-PV foci (RA, high right atrium; CS, coronary sinus; HD, Advisor™ HD Grid catheter; H, Halo Duodecapolar catheter).

Figure 3. The earliest atrial activation site during AF initiation. (A) A 3-D mapping system revealed that the Advisor™ HD Grid catheter was situated at the prominent Eustachian ridge. The green tag was marked at the earliest atrial activation site of the C-spline of the Advisor™ HD Grid catheter. (B) After the Advisor™ HD Grid catheter was pulled out, the ablation catheter was positioned at the green tag sites. Intracardiac electrogram of the distal pair of the ablation catheter was the earliest activation site during

AF initiation. A couple of radiofrequency applications were performed (ABL: ablation catheter).

Fig.1

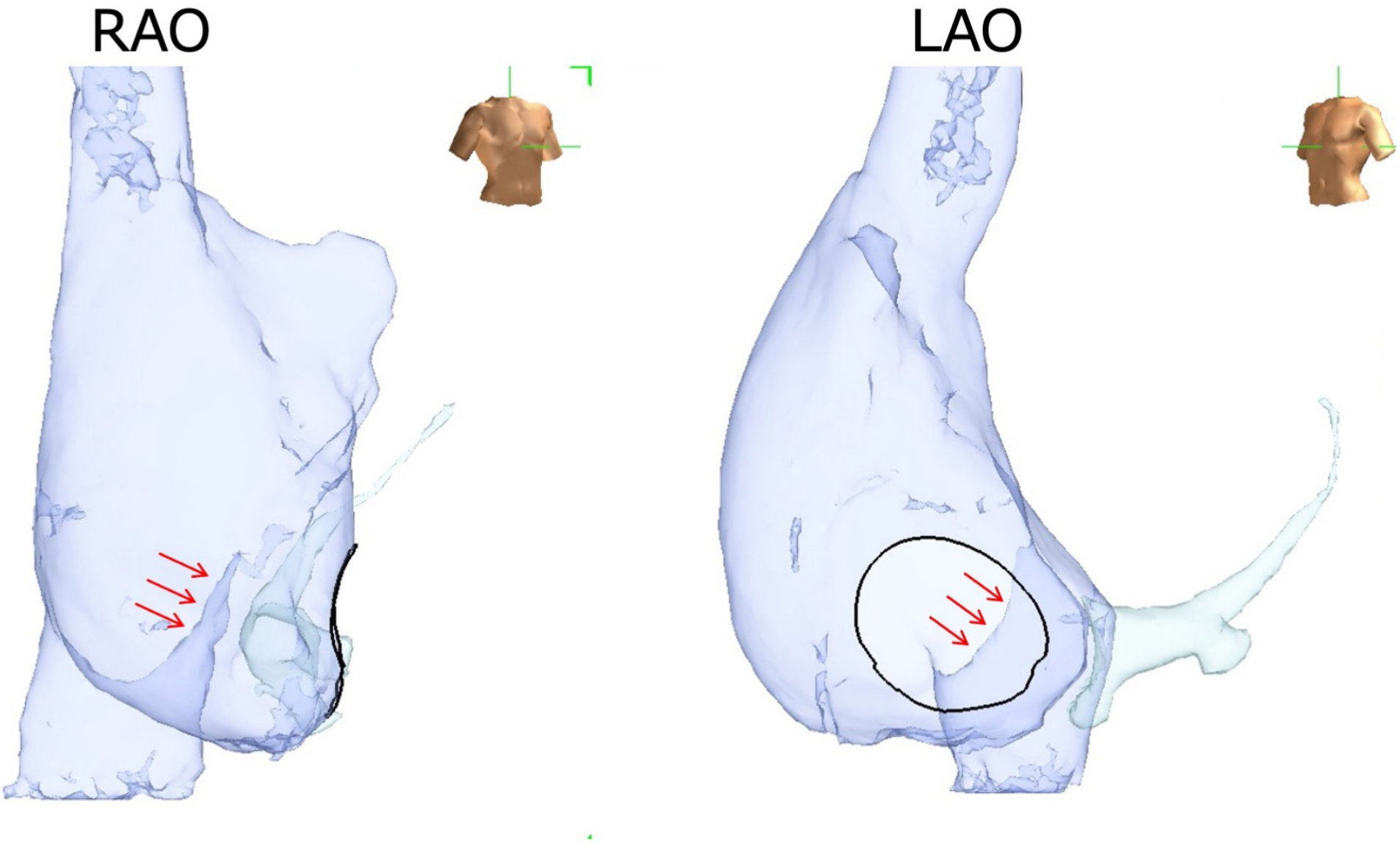
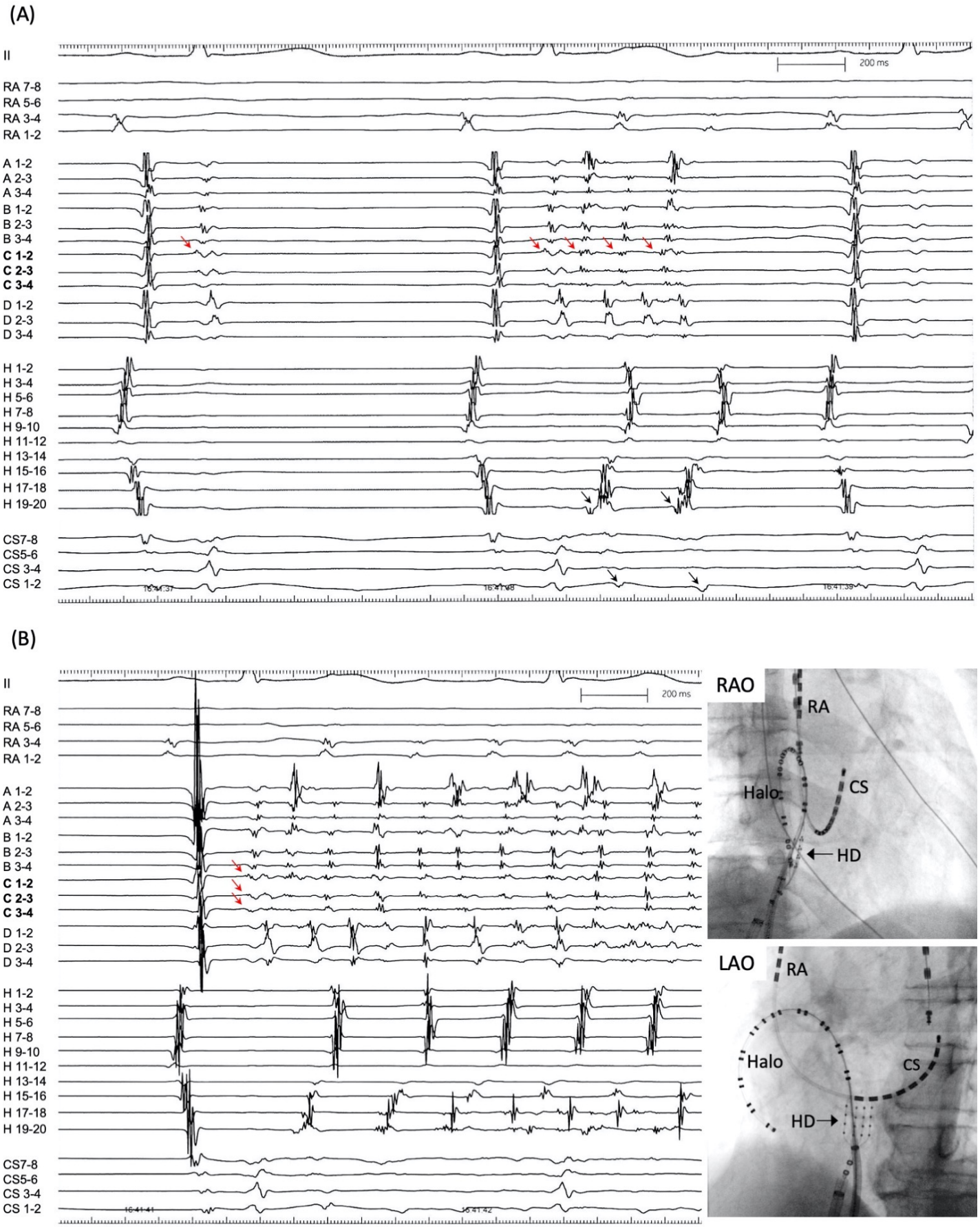


Fig. 2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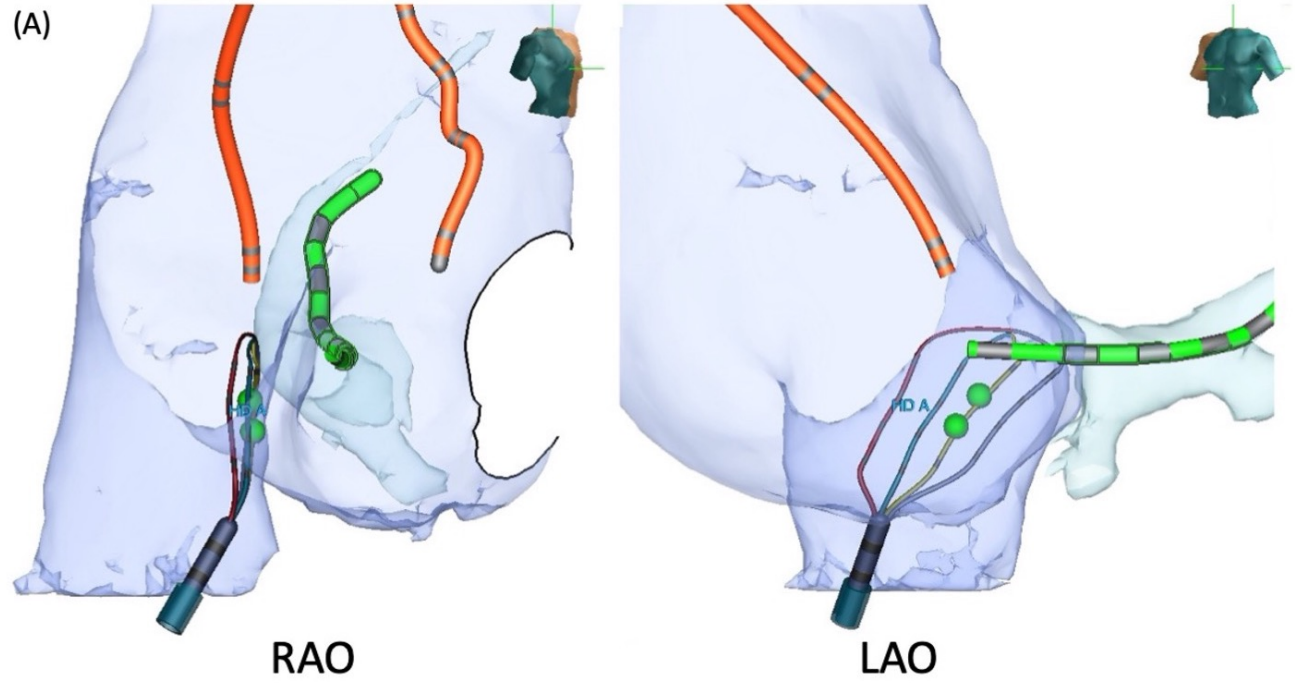
RA 5-6
RA 3-4
RA 1-2
A 1-2
A 2-3
A 3-4
B 1-2
B 2-3
B 3-4
C 1-2
C 2-3
C 3-4
D 1-2
D 2-3
D 3-4
H 1-2
H 3-4
H 5-6
H 7-8
H 9-10
H 11-12
H 13-14
H 15-16
H 17-18
H 19-20
CS7-8
CS5-6
CS 3-4
CS 1-2
(B)
II
200 ms
RA 7-8
RA 5-6
RA 3-4
RA 1-2
A 1-2
A 2-3
A 3-4
B 1-2
B 2-3
B 3-4
C 1-2
C 2-3
C 3-4
D 1-2
D 2-3
D 3-4
H 1-2
H 3-4
H 5-6
H 7-8
H 9-10
H 11-12
H 13-14
H 15-16
H 17-18
H 19-20
CS7-8
CS5-6
CS 3-4
CS 1-2
RAO
RA
Halo
CS
HD
LAO
RA
Halo
CS
HD

Fig.3


(A)
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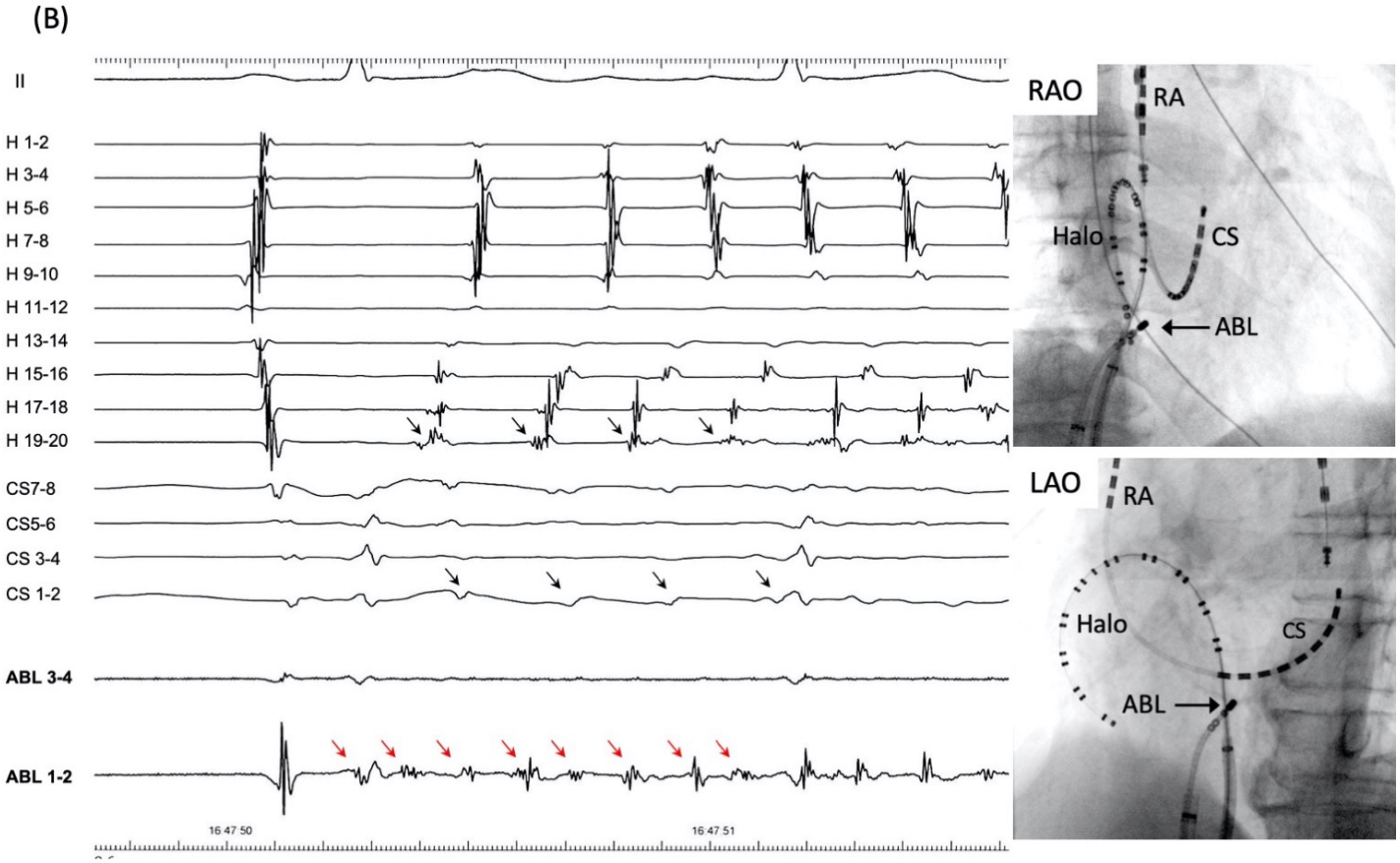
(B)
II
H 1-2
H 3-4
H 5-6
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H 15-16
H 17-18
H 19-20
CS7-8
CS5-6
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CS 1-2
ABL 3-4
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16 47 50
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RAO
RA
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CS
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LAO
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