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Case report

Optimal treatment of biatrial tachycardia diagnosed by one-chamber mapping within an ultrahigh-resolution mapping system

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ABSTRACT

Biatrial tachycardia (BiAT) is a rare arrhythmia, and identification of the re-entry circuit is often complicated. By creating an activation map of the right atrium, left atrium, and coronary sinus as a single chamber, the LUMIPOINT module of the Rhythmia mapping system (Boston Scientific, Marlborough, MA, USA) can be used in real time to make an accurate diagnosis. Ablation of the Bachmann bundle is a feasible way to terminate BiAT, but might cause interatrial conduction delay and electrical isolation of the left atrial appendage. Chemical ablation into the vein of Marshall might be the more beneficial treatment, avoiding any potential interatrial conduction delay.

Introduction

Biatrial tachycardia (BiAT) is a rare and complex macroreentrant atrial tachycardia (AT) that circulates through both the right (RA) and left atria (LA) [1]. High-resolution mapping has been reported to be useful for the diagnosis and treatment of tachycardia circuits in individuals with widespread atrial incision lines and disrupted potentials [2]. Especially, the Lumipoint module of the Rhythmia mapping system (Boston Scientific, Marlborough, MA, USA) is useful for identifying complex arrhythmia circuits [2]. However, one limitation of the Lumipoint module is that it can be applied to only one activation map. When BiAT was suspected in the case we present here, we circumvented the Lumipoint limitation by taking all activation mapping (RA, LA, and CS) to the same chamber (ONECHAN map technique), allowing the Lumipoint module to be used during the case for the diagnosis of BiAT and the use of EIVOM, which was effective in treating the patient's BiAT.

Case report

A 58-year-old man with a history of three catheter ablations (CA) for persistent atrial fibrillation and AT underwent pulmonary vein isolation, posterior wall isolation, cavotricuspid isthmus ablation, and anterior and lateral lines of mitral isthmus (MI) ablation. However, one year after his final treatment, the patient developed palpitations attributed to AT. Because of difficulties in rate and rhythm control with medications, the patient therefore required a fourth CA.

Rhythm at presentation was sustained AT with 2:1 atrioventricular conduction, a tachycardia cycle length (TCL) of 310 ms (Fig. 1A), a reverse chevron CS electrode sequence, and RA conduction from high to low RA (Fig. 1B). Based on the AT sequence, the AT was suspected to originate in the LA [3], and the LA was first mapped using an IntellaMap Orion catheter with the Rhythmia mapping system. The LA voltage map revealed scarring of the anterior and lateral MI lines from a previous CA. The propagation map of the LA identified a conduction block at the scar on the anterior wall of the MI line, which propagated from the ridge between the left atrial appendage (LAA) and the left superior pulmonary vein (LSPV) through the LA roof toward the right pulmonary vein, with a collision at the LA septum, where the excitation propagated up and down (Video S1). The LA alone met the TCL for only 210 ms (67.4 %), and a 100 ms missing area was evident. Because involvement of the epicardial connection and BiAT were suspected in this case, activation maps of the RA and CS were obtained as additions to the activation map of the LA. Although the local activation time was 310 ms, a 46 ms missing time when propagating from the RA to the LA and a 54 ms missing time when propagating from the CS to the LA were observed. On review, the mapping in the LUMIPOINT module was similar to that in the propagation map: no myocardial activation was observed during propagation from the LA to the RA and from the

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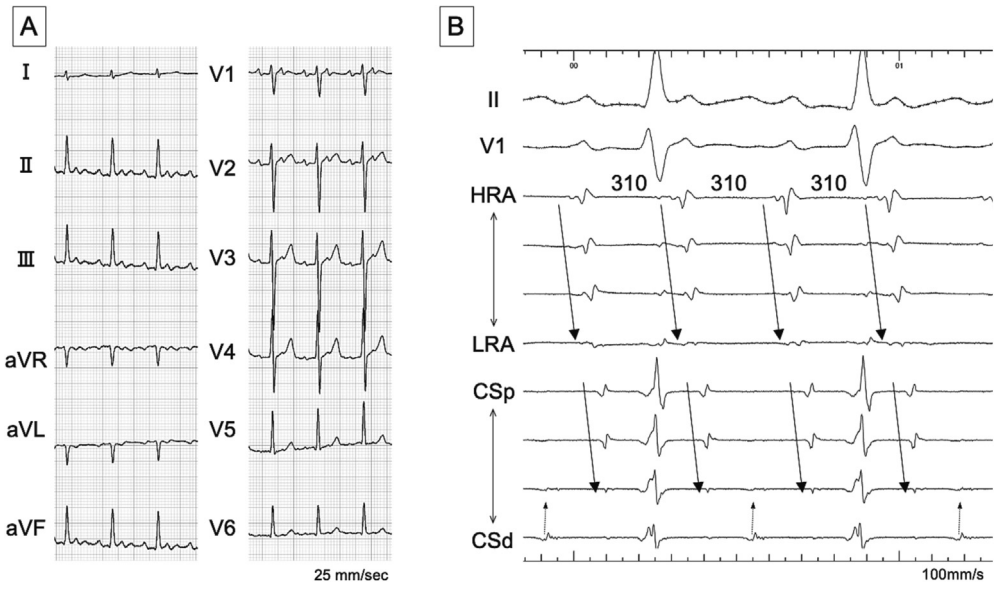

Fig. 1. (A) Twelve-lead electrocardiography showed clinical atrial tachycardia (AT) with 2:1 atrioventricular conduction. (B) Intracardiac electrograms taken during the clinical AT. The tachycardia cycle length was 310 ms. The coronary sinus electrode sequence was the reverse chevron type.
HRA, high right atrium; LRA, low right atrium; CSp, proximal coronary sinus; CSd, distal coronary sinus.

CS to the LA, suggesting the involvement of epicardial connections. The anatomic Bachmann bundle and the vein of Marshall (VOM) conduction were therefore included in the BiAT in this case (Video S2).

When entrainment pacing was performed at the LA roof, RA septum, CS ostium, and LAA, the post pacing interval (PPI) – TCL was, respectively, +2 ms, +0 ms, +20 ms, and +20 ms at those sites. Thus, all

Fig. 2. ONECHAN map with high-resolution activation maps demonstrating biatrial tachycardia, a counterclockwise single-loop macro reentrant tachycardia. The yellow arrows represent the circuit of biatrial tachycardia. The white dotted arrows represent bystander propagations. The double red lines represent blocked lines from previous catheter ablations, which respectively created an anterior and a lateral mitral annulus line. In local activation histogram, areas of electrical silence for a total of 100 ms (46 ms and 54 ms) are observed through the Bachmann bundle (pink line) and the vein of Marshall (green line).
CS, coronary sinus; IVC, inferior vena cava; SVC, superior vena cava; LIPV, left inferior pulmonary vein; LSPV, left superior pulmonary vein; LAA, left atrial appendage; RA, right atrium; RAA, right atrial appendage; RSPV, right superior pulmonary vein; RIPV, right inferior pulmonary vein.

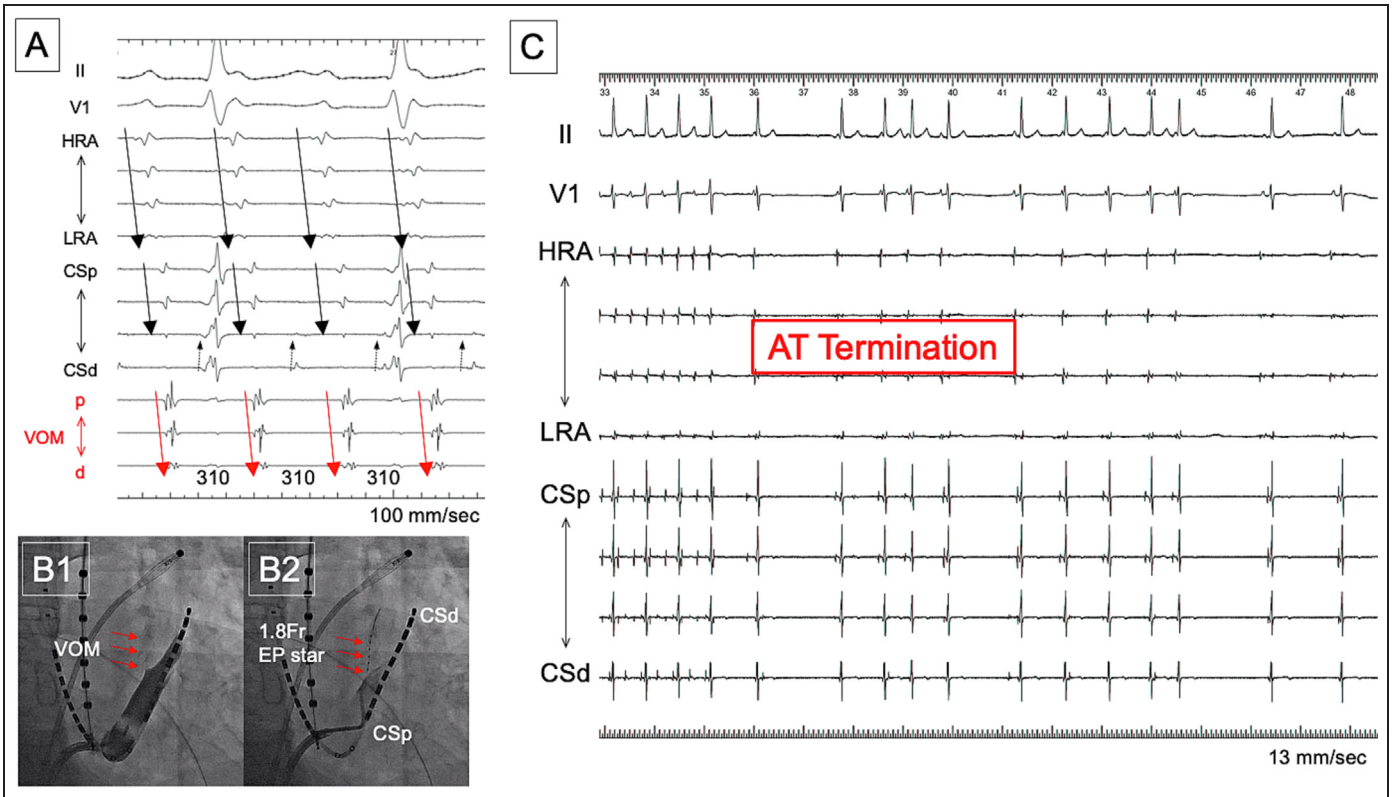

Fig. 3. (A) Intracardiac electrograms obtained with a 1.8 Fr EPstar catheter at the vein of Marshall (VOM) during clinical atrial tachycardia (AT). The conduction sequence of the electrode in the VOM was from proximal to distal. (B1) Selective coronary sinus (CS) contrast confirmed the presence of the VOM. (B2) The 1.8 Fr EPstar catheter was advanced over the guidewire. (C) After an injection of dehydrated ethanol to the VOM, AT terminated after 57 s, with prolongation of the cycle length.
HRA, high right atrium; LRA, low right atrium; CSp, proximal coronary sinus; CSd, distal coronary sinus; VOM, vein of Marshall; AT, atrial tachycardia.

PPI measurement sites were on the circuit, diagnosed as macro reentrant arrhythmia (Fig. 2). After the presence of the VOM was confirmed by selectively contrasting the CS with a 5 Fr internal mammary artery diagnostic catheter (Terumo, Tokyo, Japan), a 1.8 Fr EPstar catheter (Japan Lifeline, Tokyo, Japan) was inserted (Fig. 3B). The VOM was diagnosed to be on the tachycardia circuit because the conduction in the VOM during AT was from the CS to the LAA-LSPV ridge (Fig. 3A), and the PPI - TCL at VOM was +5 ms. Because delivering radiofrequency (RF) energy at the Bachmann bundle was considered high risk for exacerbating the LAA conduction delay, the VOM was selected as the treatment target. After the 1.8 Fr EPstar catheter was removed, a Runthrough wire (Terumo) and a 2-mm over-the-wire balloon catheter (Emerge: Boston Scientific) were guided to the VOM, and the balloon was wedged. Dehydrated ethanol was then injected, and at 57 s after injection, the BiAT terminated with a prolonged TCL (Fig. 3C). A total of 4 mL of dehydrated ethanol was injected for chemical ablation. Then, RF energy was added from the endocardial side of the lateral MI line using the IntellaNav StablePoint (Boston Scientific). LA activation mapping under low RA pacing after the CA showed that conduction of the LA and LAA remained from the RA through the Bachmann bundle (Video S3). The voltage map of the LA after CA showed that the low-voltage area on the endocardial side of the lateral MI spread wider than that before CA (Online Figs. S1, S2). One year after the CA, no recurrence of AT or atrial fibrillation has been observed.

Discussion

BiAT often occurs in patients with a prior history of CA, often caused by a conduction delay in the atrial septum. Although diagnosis can be challenging, ultra high-resolution mapping is valuable in visualizing and identifying tachycardia circuits [4,5]. LUMIPOINT can highlight all purely excitatory regions regardless of amplitude and annotation, and SKYLINE can present the excitatory area as a histogram. However, LUMIPOINT and SKYLINE analyses of multiple overlying LA and RA maps are functionally impossible if the maps were created with separate chambers.

LUMIPOINT cannot unify and analyze different chambers during CA procedures. In our case, acquiring the same map without separating the chambers allowed us to apply the LUMIPOINT module even in BiAT, for a more accurate and useful diagnosis (Online Method S1). Although it is possible to suspect BiAT, the ONECHAN map may provide a more definitive diagnosis. Tanaka et al. reported that, LA in SKYLINE reveals a discontinuous plateau period, raising suspicion of a pseudofocal pattern [2]. Macro reentrant ATs, including epicardial circuits such as the VOM, might present a pseudofocal pattern. In cases in which BiAT is suspected, using the ONECHAN map to simultaneously display the RA, LA, and CS can be useful for identifying the tachycardia circuit. In our case, SKYLINE of the ONECHAN map revealed missing zones of 46 ms and 54 ms local activation time (100 ms in total), suggesting epicardial conduction through the Bachmann bundle and the VOM respectively (Online Fig. S3). In combination with the LUMIPOINT ^{findings}, those results confirmed the diagnosis of BiAT.

The appropriate target site for ablation of BiAT in patients with atrial septal conduction delay remains controversial given the potential for exacerbating RA–LA conduction defects or inducing conduction defects to the LAA, depending on the site of the RF ablation. The present case consisted of a type 2 BiAT involving the LA and RA septum [1]. In this type 2 BiAT, the Bachmann bundle in the delayed conduction pathway or the lateral MI line is often the target for treatment. Dissecting the Bachmann bundle in a CA for BiAT has been reported to be effective, but also risks inducing a conduction delay in the LAA [6]. In the present case, the anterior and lateral MI lines were both established, and the possibility of a conduction delay in the LAA was evident before treatment. Both lines exhibited conduction via the epicardial bridge between

the Bachmann bundle and the VOM; however, if the Bachmann bundle were to be disconnected, conduction to the LAA would occur via the CS to the VOM to the LAA. The potential for further conduction delay was thus deemed significant, and additional endocardial treatment of the Bachmann bundle would have been required. Instead, ethanol infusion into the VOM (EIVOM) was performed because of the possibility of direct treatment by chemical ablation.

A 98.7 % success rate of EIVOM for bidirectional conduction block of the MI has been reported when combined with RF ablation [7]. In the case of BiAT, which can occur in patients who have already undergone endocardial block line of the MI, EIVOM could be a highly effective treatment when the circuit includes epicardial conduction through the VOM, as in the present case. Although little has been reported on EIVOM for BiAT, Lai et al. reported on ablation strategies for 20 cases of BiAT and performed EIVOM for 5 cases [8]. It should be acknowledged that EIVOM has been associated with potential complications such as local pericarditis, dissection of the VOM, and leakage of contrast media [9]. EIVOM is a well-established therapeutic approach supported by prior studies [10] and should be considered a viable option for cases in which creating an MI block line is difficult or a BiAT circuit includes the VOM.

Conclusions

ONECHAN map is beneficial for the diagnosis of BiAT, and EIVOM might be more useful than RF ablation to the Bachmann bundle as a direct treatment for BiAT.

Supplementary data to this article can be found online at https://doi.org/10.1016/j.jccase.2023.09.001.

CRediT authorship contribution statement

1) YM and KY devised the study design and concept. YM analyzed and interpreted the data.
2) YM and KY drafted the manuscript. DK, MM, KO, and TN performed critical revision for important intellectual content.
3) All authors approved the final version of the manuscript.

Patient permission/Consent statement

Written informed consent was obtained from the patient for publication of this case report and accompanying images.

Declaration of competing interest

The authors have no conflicts to disclose. Written patient consent was received for the publication of this article.

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None.

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