

Left atrial roof–dependent atrial tachycardia via the Marshall bundle



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Introduction

Left atrial (LA) roof–dependent atrial tachycardias (ATs) are one of the common forms of iatrogenic ATs after a percutaneous or surgical LA ablation of atrial fibrillation (AF). The reentrant circuits of LA roof–dependent ATs generally rotate around either or both of the right and left pulmonary veins (RPVs and LPVs). We present an unusual case of an LA roof–dependent AT with dual reentrant circuits: one rotating around the RPVs and the other around the LPVs, passing through the vein of Marshall (VOM).

Case report

A 70-year-old woman with a previous catheter ablation of persistent AF, including a PV isolation and linear ablation along the superior and inferior lines of the posterior LA and lateral mitral isthmus (MI), underwent a second procedure for a recurrent AT with a tachycardia cycle length (TCL) of 350 ms (Figure 1A). High-resolution activation mapping of the LA and VOM using the Rhythmia system (Boston Scientific, Marlborough, MA) with a mini-basket catheter (IntellaMap Orion; Boston Scientific) and 1.6F multielectrode catheter (EPSkinny; FMD Co, Ltd, Tokyo, Japan) suggested that the clinical AT was an LA roof–dependent AT with dual reentrant circuits: one rotating around the RPVs and the other around the LPVs, passing through the VOM (Figure 1B–1E, Supplemental Online Video). Entrainment pacing from the VOM during the AT demonstrated that the postpacing interval was 356 ms and similar to the TCL, and the electrograms recorded in the posterior LA were orthodromically captured during the pacing (Figure 2A–2B). Further, the postpacing interval was almost similar to the TCL upon entrainment from the

KEY TEACHING POINTS

- The present case exhibited an unusual form of a left atrial (LA) roof–dependent atrial tachycardia (AT) with dual reentrant circuits: one rotating around the right pulmonary veins (PVs) and the other around the left PVs, passing through the vein of Marshall (VOM).
- High-resolution activation mapping combined with entrainment pacing from not only the LA endocardium but also the VOM could be helpful to establish an accurate diagnosis of the LA roof–dependent AT mechanism.
- An ethanol infusion into the VOM can be one of the therapeutic options for treating LA roof–dependent ATs via the Marshall bundle.

anterior, inferior, posterior, and septal LA, but was not upon entrainment from the lateral mitral annulus, LA appendage (LAA), and ridge between the LAA and LPVs (Figure 1B–1E). A 5 mL ethanol infusion into the VOM terminated the AT after a gradual prolongation of the TCL from 350 ms to 380 ms (Figure 2C). After the ethanol infusion with a total of 10 mL, voltage and activation mapping exhibited the elimination of the electrograms in the VOM, LPVs, ridge, and majority of the lateral and posterior LA, as well as the creation of bidirectional conduction block along the superior line of the posterior LA (Figure 3). Additional radiofrequency applications completed the electrical isolation of the posterior LA and bidirectional conduction block along the MI.

KEYWORDS Atrial tachycardia; Catheter ablation; High-resolution mapping; Left atrial roof; Marshall bundle
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Discussion

This is a case report demonstrating that the Marshall bundle was included in the reentrant circuit of the dual-loop LA roof–dependent AT. Some reentrant ATs after a percutaneous or surgical AF ablation have been reported to have epicardial pathways via the Marshall bundle, such as

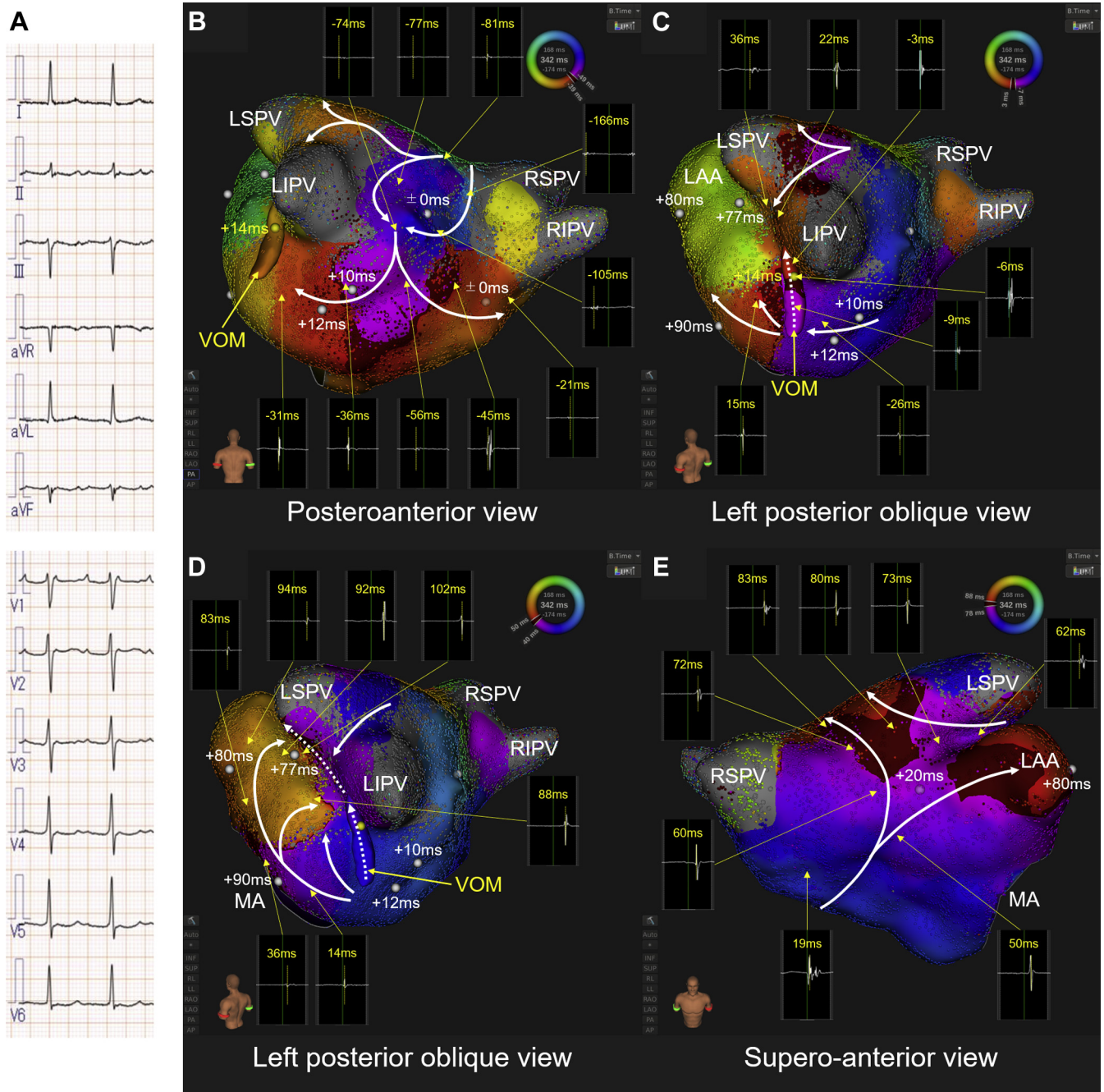


Figure 1 A: Twelve-lead electrocardiogram during the clinical atrial tachycardia (AT) with a tachycardia cycle length (TCL) of 350 ms. B–E: High-resolution activation mapping exhibiting a dual-loop left atrial (LA) roof-dependent AT. One reentrant circuit was rotating around the right pulmonary vein (PVs) after propagating through the LA roof toward the posterior left atrium and the other was rotating around the left PVs, passing through the vein of Marshall (VOM) (Online Video). The numbers in the local electrograms indicate the intervals from the reference electrogram recorded in the coronary sinus to the local electrogram. The white and yellow tags and numbers on the maps indicate the entrainment pacing sites in the left atrium and VOM and the postspaced interval minus TCL (ms), respectively. The white solid and dotted arrows and dark red on the maps represent the endocardial activation propagation, suspected epicardial activation propagation via the VOM, and activation wavefront during the AT, respectively. The confidence mask of the maps was set at 0.03 mV. LAA = left atrial appendage; LIPV = left inferior pulmonary vein; LSPV = left superior pulmonary vein; MA = mitral annulus; RIPV = right inferior pulmonary vein; RSPV = right superior pulmonary vein.

perimitral ATs, or ridge-related or Marshall-related reentrant ATs.^{1–7} To the best of our knowledge, there have been no previous studies reporting an LA roof-dependent AT via the Marshall bundle.

The VOM usually arises from the coronary sinus in the posterolateral region of the LA and courses epicardially between the LAA and LPVs. Since the VOM has various venous branches,^{8,9} the extent of the ablation lesion obtained by an

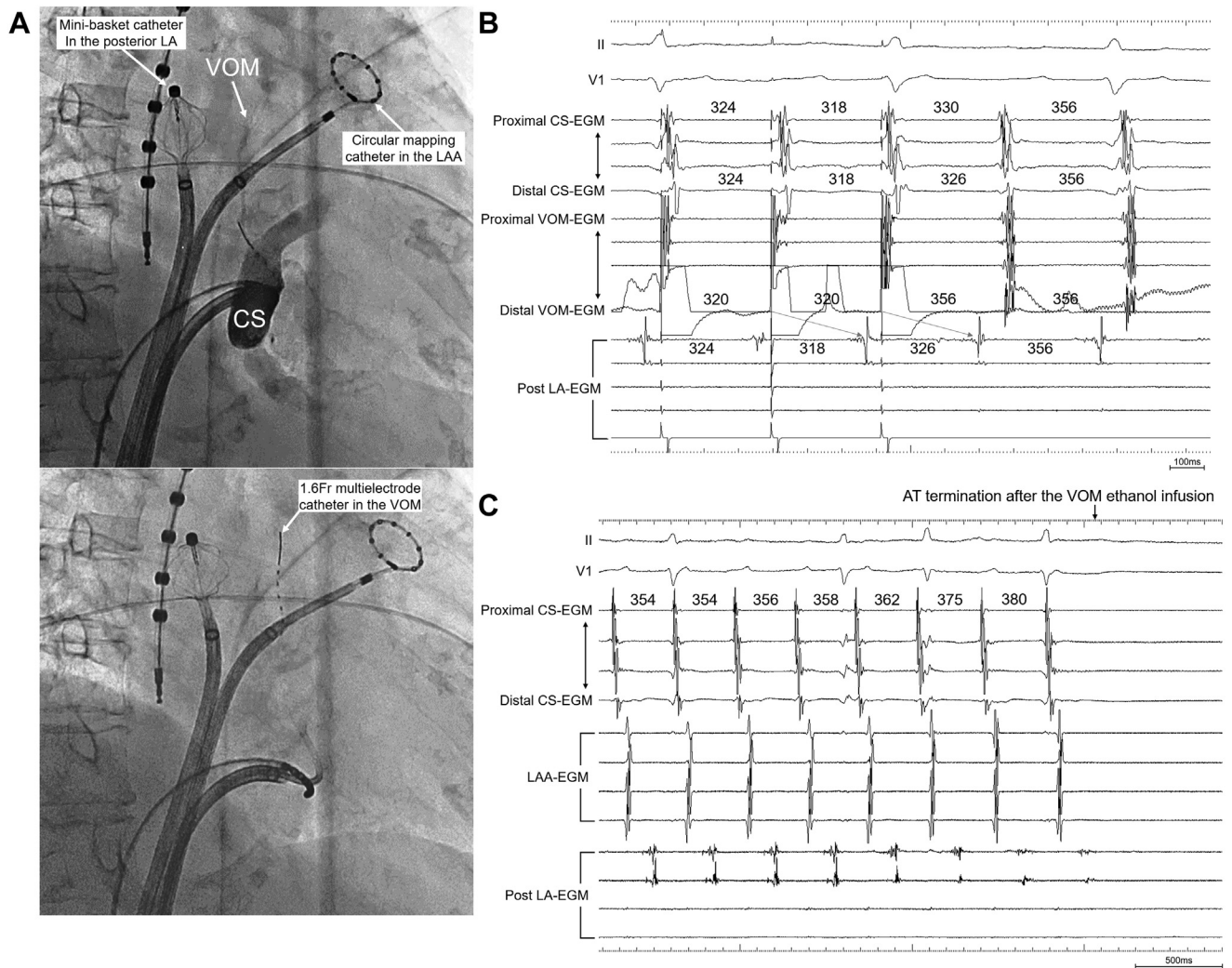


Figure 2 A: Fluoroscopic images showing the course of the VOM on retrograde VOM venography (upper panel) and the position of a 1.6F multielectrode catheter (EPSkinny; FMD Co, Ltd, Tokyo, Japan) placed in the VOM (lower panel) in the right anterior oblique 35 degrees. The mini-basket and circular mapping catheters are placed in the posterior left atrium and LAA, respectively. B: Entrainment pacing from the VOM (Distal VOM-EGM) demonstrating that the post-pacing interval was 356 ms and similar to the TCL. The third and fourth electrograms recorded in the posterior left atrium (Post LA-EGMs) were orthodromically captured (red arrows), while the electrograms along the VOM (VOM-EGMs) were antidromically captured during pacing. The configuration of the second posterior left atrial (LA) electrogram differed from that of the other posterior LA electrograms, and the second activation sequences along the VOM and coronary sinus slightly differed from the first and third activation sequences during pacing. Thus, the second beat probably represented the fusion of the pacing and an atrial premature contraction. C: AT termination with a gradual prolongation of the TCL from 350 ms to 380 ms after a 5 mL ethanol infusion into the VOM. CS-EGM = coronary sinus electrogram recordings; LAA-EGM = intracardiac electrograms recorded by the circular mapping catheter in the LAA; Post LA-EGM = intracardiac electrograms recorded by the mini-basket catheter in the posterior LA; VOM-EGM = intracardiac electrograms recorded in the VOM; other abbreviations as in Figure 1.

ethanol infusion into the VOM varies according to the extent of the VOM branches. A VOM ethanol infusion can create an ablation lesion along the MI area and ridge between the LAA and LPVs, which sometimes extends to the LA posterior wall and roof.^{4,9-13} Also in the present case, the VOM ethanol infusion eliminated the electrograms in not only the VOM but also the LA posterior wall and roof, and concurrently created bidirectional conduction block along

the LA roof in conjunction with the previous LA roof linear ablation.

Detailed mapping using the high-resolution mapping system combined with entrainment pacing from not only the LA endocardium but also the VOM could be helpful to establish an accurate diagnosis of the mechanisms of LA roof-dependent ATs. A VOM ethanol infusion can be one of the therapeutic options for treating some kinds of LA roof-dependent ATs.

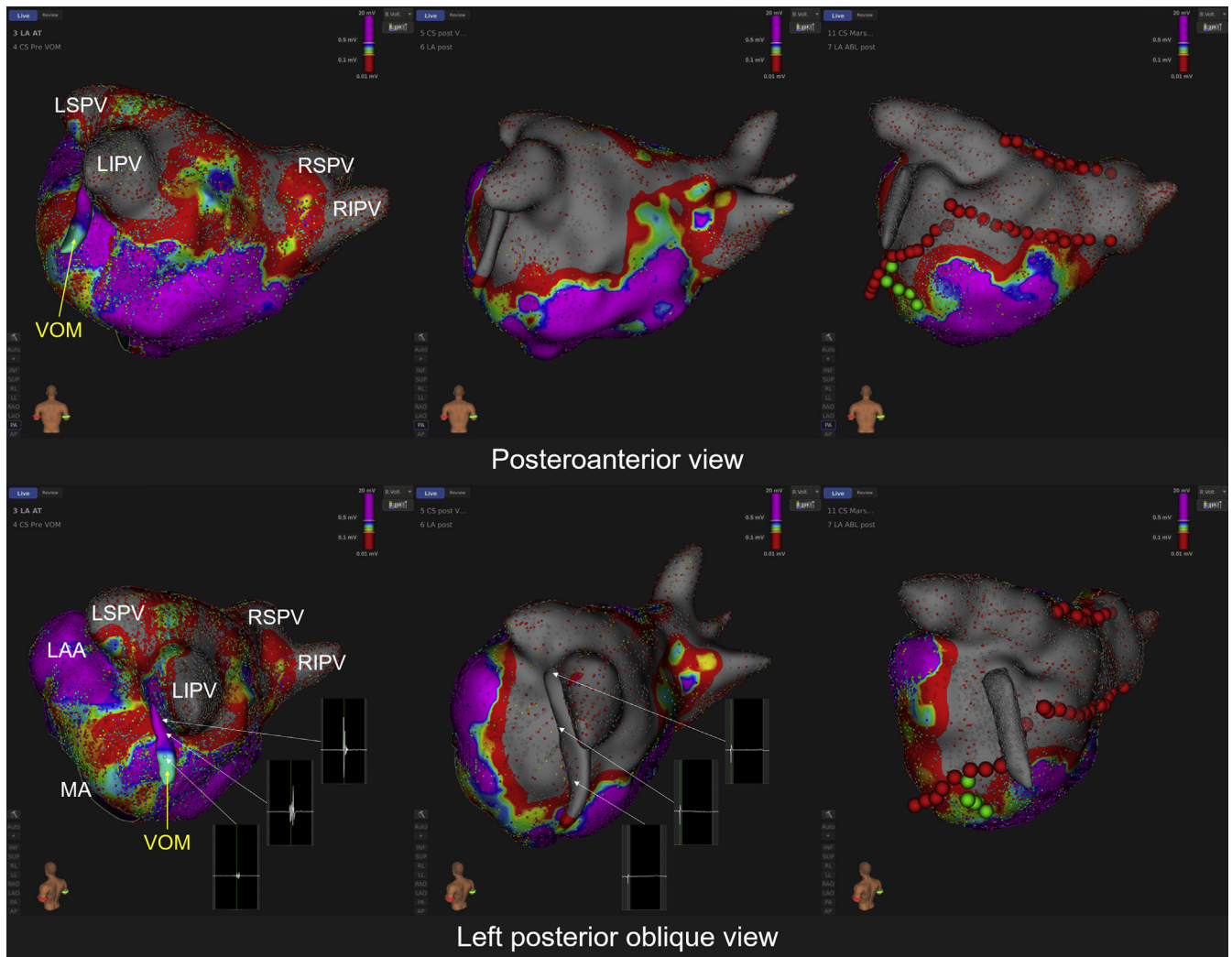


Figure 3 Bipolar voltage maps (A) before and (B) after the VOM ethanol infusion and (C) after additional radiofrequency applications along the superior and inferior lines of the posterior left atrium (LA), lateral mitral isthmus (MI), and coronary sinus (CS). The VOM ethanol infusion eliminated the electrograms in the VOM, ridge between the LAA and LPVs, and majority of the lateral and posterior LA. Additional radiofrequency applications completed the electrical isolation of the posterior LA and bidirectional conduction block along the MI. The light green and red tags represent the radiofrequency ablation sites in the CS and those along the superior and inferior lines of the posterior LA and MI, respectively. The low voltage and scar areas were defined as areas with bipolar electrogram amplitudes of <0.5 mV and <0.1 mV, respectively. Other abbreviations as in Figure 1.

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Appendix

Supplementary data

Supplementary data associated with this article can be found in the online version at <https://doi.org/10.1016/j.hrcr.2021.05.010>.

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