Indian Pacing and Electrophysiology Journal 21 (2021) 241–244

Contents lists available at ScienceDirect

Indian Pacing and Electrophysiology Journal

journal homepage: www.elsevier.com/locate/IPEJ

What are the post-ablation insular residual electrograms in the posterior left pulmonary veins electrically connected to?

Kohki Nakamura [a,*], Masateru Takigawa [b], Takehito Sasaki [a], Kentaro Minami [a], Shigeto Naito [a]

[a] Division of Cardiology, Gunma Prefectural Cardiovascular Center, 3-12 Kameizumi-machi, Maebashi City, Gunma, 371-0004, Japan
[b] Department of Cardiovascular Medicine, Tokyo Medical and Dental University, 1-5-45 Yushima, Bunkyo City, Tokyo, 113-8510, Japan

ARTICLE INFO

Article history:
Received 19 January 2021
Received in revised form
11 March 2021
Accepted 30 April 2021
Available online 13 May 2021

Keywords:
Atrial fibrillation
Ethanol infusion
Perimitral atrial tachycardia
Pulmonary vein isolation
Vein of Marshall

ABSTRACT

A 67-year-old man underwent a third ablation procedure for a recurrent atrial tachycardia (AT) after an extensive pulmonary vein (PV) isolation, linear ablation along the left atrial (LA) roof and posterolateral mitral isthmus (MI), and defragmentation of persistent atrial fibrillation and an induced perimitral AT. High-resolution mapping during the clinical AT using the Rhythmia system (Boston Scientific) suggested that the AT was a ridge-related reentrant AT and exhibited a reconnection of the left PVs (LPVs). The residual electrograms in the posterior LPVs were surrounded by endocardial scar, which was like an island consisting of residual LPV electrograms. Retrograde venography of the vein of Marshall (VOM) demonstrated that the VOM reached the posterior left superior PV through the ridge between the LA appendage and left inferior PV and then the LPV carina. An ethanol infusion into the VOM resulted in a simultaneous AT termination and complete electrical isolation of the LPVs, that is, the disappearance of the residual LPV electrograms. The insular residual LPV electrograms in the present case did not appear to be endocardially connected to the LA, because the LPV electrograms were surrounded by endocardial scar and there was a large time gap between the earliest activation in the posterior LPVs and activation in the surrounding area. The VOM course on the venography and elimination of the residual LPV electrograms with an ethanol infusion into the VOM suggested that the insular residual LPV electrograms were electrically connected to the posterolateral LA via the VOM and its branches.

1. Introduction

Some residual connections between the left pulmonary veins (LPVs) and left atrium (LA) during an extensive PV isolation of atrial fibrillation (AF) are associated with epicardial conduction via the vein of Marshall (VOM) or subepicardial myocardial strands [1–5]. Those epicardial connections are sometimes difficult to eliminate with touch-up radiofrequency ablation on the initial PV isolation lines, and require additional radiofrequency applications inside the initial PV isolation lines, such as at the carina region, to complete the electrical isolation of the PVs. We present a case with the insular residual electrograms in the posterior LPVs after an extensive PV isolation, which did not appear to be endocardially connected to the LA on high-resolution mapping. The VOM course on venography and the elimination of the residual LPV electrograms with an ethanol infusion into the VOM suggested that the insular residual LPV electrograms were electrically connected to the posterolateral LA via the VOM and its branches.

2. Case report

A 67-year-old man underwent a third ablation procedure for a recurrent atrial tachycardia (AT) with a tachycardia cycle length of 260 ms. The first procedure for persistent AF consisted of an extensive PV isolation, linear ablation along the left atrial (LA) roof, and defragmentation. The second procedure consisted of a re-isolation of the left inferior PV (LIPV) and linear ablation along the posterolateral mitral isthmus (MI) for an induced perimitral AT. During the third procedure, high-resolution mapping during the clinical AT using the Rhythmia system (Boston Scientific, Marlborough, MA) and a mini-basket catheter (IntellaMap Orion, Boston Scientific) suggested that the AT was a ridge-related reentrant AT

* Corresponding author.
E-mail address: kohkinakamura@yahoo.co.jp (K. Nakamura).
Peer review under responsibility of Indian Heart Rhythm Society.

https://doi.org/10.1016/j.ipej.2021.04.008

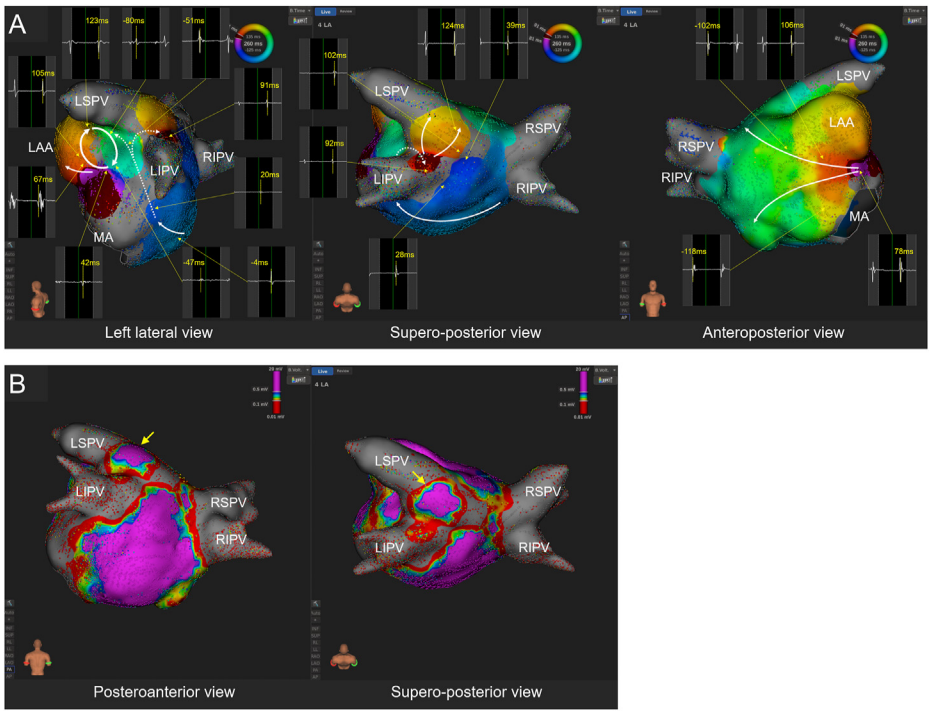

Fig. 1. (A) Activation maps during the AT suggesting a ridge-related reentrant AT (Online Video 1). The numbers in the local electrograms indicate the intervals from the reference electrogram recorded in the coronary sinus to the local electrogram. The white solid and dotted arrows represent the endocardial activation propagation and possible epicardial conduction pathway via the VOM and its branches, respectively. (B) Bipolar voltage maps during the AT exhibiting insular residual LPV electrograms surrounded by endocardial scar (yellow arrows). The low voltage and scar areas were defined as areas with bipolar electrogram amplitudes of <0.5 mV and <0.1 mV, respectively. Abbreviations: LAA, left atrial appendage; LIPV, left inferior pulmonary vein (PV); LSPV, left superior PV; MA, mitral annulus; RIPV, right inferior PV; RSPV, right superior PV.

(Fig. 1A, Online Video 1), and exhibited an LPV reconnection. The residual electrograms in the posterior region of the LPVs were surrounded by endocardial scar, which was like an island consisting of residual LPV electrograms (Fig. 1B). Retrograde venography of the VOM demonstrated that the VOM reached the posterior left superior PV (LSPV) through the ridge between the LA appendage (LAA) and LIPV and then the carina between the LPVs (Fig. 2, Online Video 2). An ethanol infusion into the VOM terminated the AT after a gradual prolongation of the tachycardia cycle length from 260 ms to 310 ms and concurrently electrically isolated the LPVs (Fig. 3). After the ethanol infusion with a total of 5 mL, voltage mapping exhibited the complete elimination of the insular residual LPV electrograms (Fig. 4).

Supplementary video related to this article can be found at https://doi.org/10.1016/j.ipej.2021.04.008

3. Discussion

This was a case report describing the complete elimination of the post-ablation insular residual electrograms in the posterior

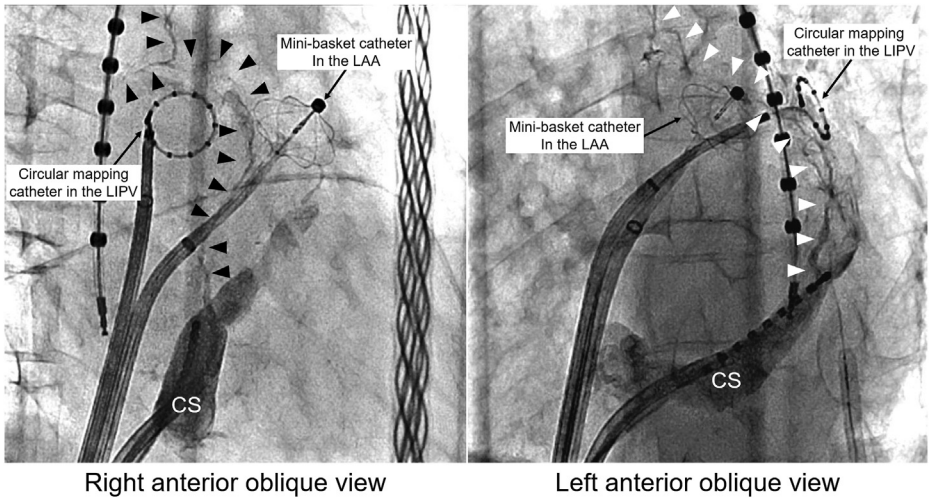

Fig. 2. Fluoroscopic images showing the course of the VOM and its branches (black and white arrowheads) (Online Video 2). The mini-basket catheter and circular mapping catheter are placed in the LAA and LIPV, respectively. Abbreviations: CS, coronary sinus. The other abbreviations are as in Fig. 1.

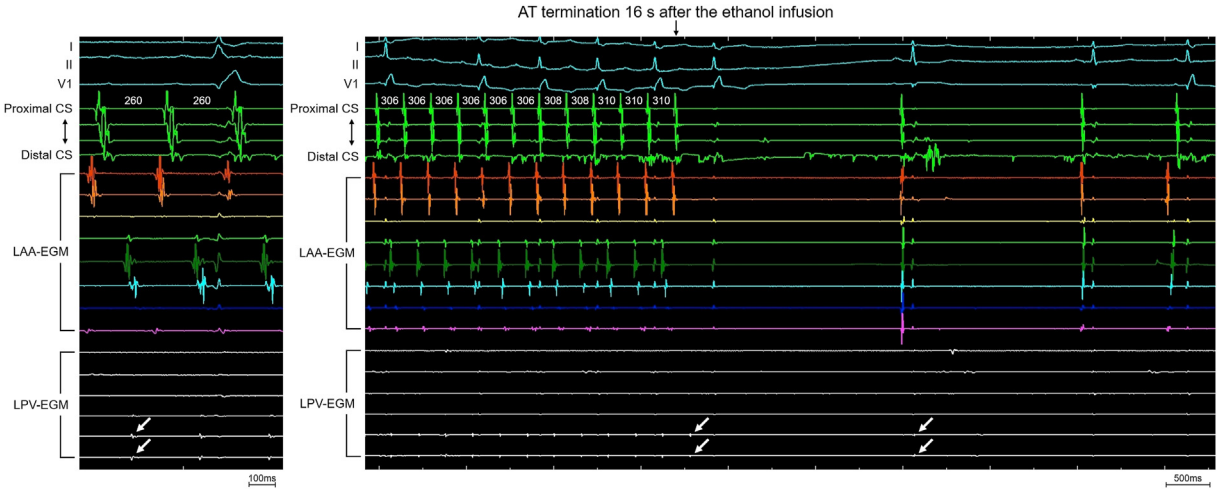

Fig. 3. Simultaneous AT termination after a gradual prolongation of the tachycardia cycle length from 260 ms to 310 ms and electrical isolation of the LPVs 16 s after the ethanol infusion of 2.5 mL into the VOM. The left and right panels show the intracardiac electrograms at the beginning of the VOM ethanol infusion and those when the AT was terminated and residual LPV electrograms (white arrows) eliminated, respectively. Abbreviations: CS, coronary sinus recordings; LAA-EGM, mini-basket catheter recordings in the LAA; LPV-EGM, circular mapping catheter recordings in the LIPV.

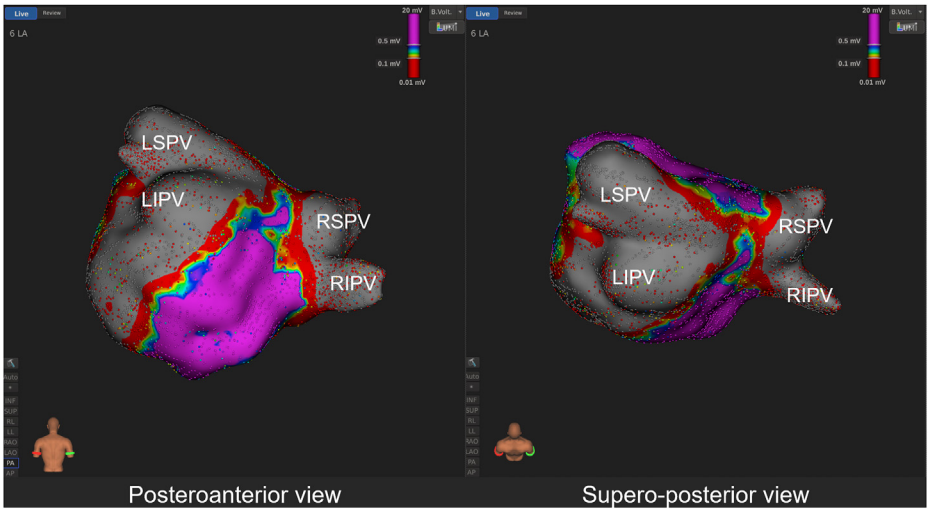

Fig. 4. Bipolar voltage maps after the ethanol infusion exhibiting the complete elimination of the insular residual LPV electrograms. The low voltage and scar areas were defined as areas with bipolar electrogram amplitudes of <0.5 mV and <0.1 mV, respectively. The abbreviations are as in Fig. 1.

LPVs with an ethanol infusion into the VOM. The VOM course on venography and the elimination of the LPV electrograms with the VOM ethanol infusion suggested that the insular residual LPV electrograms were electrically connected to the posterolateral LA via the VOM and its branches. The residual LPV electrograms were surrounded by endocardial scar on the voltage map. Further, the activation map during the clinical AT revealed a large time gap between the earliest activation of the residual LPV electrograms and activation in the surrounding area, including the posterior and posterolateral LA and ridge, as in Fig. 1A. Those findings may indicate the absence of endocardial electrical connections between the LA and residual electrograms in the posterior LPVs.

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 [6,7], the extent of the ablation lesion obtained by an 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 [7–12]. The VOM in the present case reached the posterior LSPV, which corresponded to the area with the insular residual electrograms. Therefore, the Marshall bundles along the VOM appeared to constitute an epicardial bypass between the insular residual LPV electrograms and posterolateral LA.

A VOM ethanol infusion can be useful for not only the PV isolation but also ablation of ATs and atrial flutters refractory to conventional radiofrequency-based ablation procedures, and can facilitate the creation of conduction block along the MI and eliminate Marshall bundle-related or ridge-related ATs [3,10,11,13–15]. Also in the present study, the VOM ethanol infusion was effective in both the treatment of the AT and the LPV isolation.

Funding sources

This research did not receive any specific grant from funding agencies in the public, commercial, or not-for-profit sectors.

Declaration of competing interest

No author has a real or perceived conflict of interest.

References

[1] Cabrera JA, Ho SY, Climent V, Fuertes B, Murillo M, Sanchez-Quintana D. Morphological evidence of muscular connections between contiguous pulmonary venous orifices: relevance of the interpulmonary isthmus for catheter ablation in atrial fibrillation. Heart Rhythm 2009;6:1192–8.

[2] Perez-Castellano N, Villacastin J, Salinas J, et al. Epicardial connections between the pulmonary veins and left atrium: relevance for atrial fibrillation ablation. J Cardiovasc Electrophysiol 2011;22:149–59.

[3] Dave AS, Báez-Escudero JL, Sasaridis C, Hong TE, Rami T, Valderrábano M. Role of the vein of Marshall in atrial fibrillation recurrences after catheter ablation: therapeutic effect of ethanol infusion. J Cardiovasc Electrophysiol 2012;23:583–91.

[4] Nakamura K, Inoue M, Sasaki T, Minami K, Take Y, Naito S. Multiple epicardial connections during extensive pulmonary vein isolation. Pacing Clin Electrophysiol 2020;43:618–20.

[5] Yoshimura S, Nakamura K, Sasaki T, Minami K, Take Y, Naito S. A variant of pulmonary vein-gap reentrant atrial tachycardia with multiple epicardial conduction gaps. J Cardiol Cases 2020;22:286–90.

[6] Makino M, Inoue S, Matsuyama TA, et al. Diverse myocardial extension and autonomic innervation on ligament of Marshall in humans. J Cardiovasc Electrophysiol 2006;17:594–9.

[7] Valderrábano M, Morales PF, Rodríguez-Mañero M, Lloves C, Schurmann PA, Dave AS. The human left atrial venous circulation as a vascular route for atrial pharmacological therapies: effects of ethanol infusion. JACC Clin. Electrophysiol. 2017;3:1020–32.

[8] Valderrábano M, Liu X, Sasaridis C, Sidhu J, Little S, Khoury DS. Ethanol infusion in the vein of Marshall: adjunctive effects during ablation of atrial fibrillation. Heart Rhythm 2009;6:1552–8.

[9] Báez-Escudero JL, Keida T, Dave AS, Okishige K, Valderrábano M. Ethanol infusion in the vein of Marshall leads to parasympathetic denervation of the human left atrium: implications for atrial fibrillation. J Am Coll Cardiol 2014;63:1892–901.

[10] Takigawa M, Vlachos K, Martin CA, et al. Acute and mid-term outcome of ethanol infusion of vein of Marshall for the treatment of perimitral flutter. Europace 2020;22:1252–60.

[11] Kitamura T, Vlachos K, Denis A, et al. Ethanol infusion for Marshall bundle epicardial connections in Marshall bundle-related atrial tachycardias following atrial fibrillation ablation: the accessibility and success rate of ethanol infusion by using a femoral approach. J Cardiovasc Electrophysiol 2019;30:1443–51.

[12] Valderrábano M, Chen HR, Sidhu J, Rao L, Ling Y, Khoury DS. Retrograde ethanol infusion in the vein of Marshall: regional left atrial ablation, vagal denervation and feasibility in humans. Circ Arrhythm Electrophysiol 2009;2:50–6.

[13] Báez-Escudero JL, Morales PF, Dave AS, et al. Ethanol infusion in the vein of Marshall facilitates mitral isthmus ablation. Heart Rhythm 2012;9:1207–15.

[14] Briceño DF, Valderrábano M. Recurrent perimitral flutter due to vein of Marshall epicardial connections bypassing the mitral isthmus: response to ethanol infusion. Circ Arrhythm Electrophysiol 2014;7:988–9.

[15] Vlachos K, Denis A, Takigawa M, et al. The role of Marshall bundle epicardial connections in atrial tachycardias after atrial fibrillation ablation. Heart Rhythm 2019;16:1341–7.