Preferential properties with decremental conduction of the Marshall vein between the coronary sinus and left superior pulmonary vein

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Introduction

The ligament and vein of Marshall (VOM), with its richly innervated sympathetic and parasympathetic nerves, runs epicardially between the coronary sinus (CS) and left pulmonary veins (LPVs), and can serve as a trigger and substrate for reentry of atrial fibrillation (AF) and atrial tachycardia.[1–3] Here we describe the case of an AF patient with preferential conduction and decremental properties of the VOM between the CS and left superior pulmonary vein (LSPV).

Case report

An 81-year-old woman with no history of significant illnesses who was suffering from frequent palpitations due to AF was referred to our institution. After obtaining informed consent, electrophysiologic study and catheter ablation procedure were performed. We cannulated the VOM with a 2Fr octapolar electrode catheter (5-mm interelectrode space, EP Star, Japan Lifeline, Tokyo, Japan) through the lumen of a 6Fr decapolar CS catheter (2-8-2 mm interelectrode spacing, St. Jude Medical, Minneapolis, MN). We introduced steerable catheters into the left atrium through a single transseptal puncture site. The LSPV was mapped with 2 adjustable 20-pole catheters (Inquiry Optima, St. Jude Medical, Minneapolis, MN). A 4-mm irrigated-tip ablation catheter (St. Jude Medical, Minneapolis, MN) was positioned at an endocardial site opposite the Marshall vein just below the left inferior pulmonary vein ostium (Figures 1A and 1B). The 3-dimensional constructed geometry of the entire left atrium including the LPVs and left lateral ridge was created using the NavX system (St. Jude Medical, St. Paul, MN), and an entire voltage map of the left atrium was constructed (Figure 1C).

Pacing was delivered from the distal CS catheter simultaneously with the onset of the VOM. The recorded potentials of the VOM included high frequency deflections, and an extrastimulus revealed decremental conduction along the VOM. The conduction time between the CS and LSPV during the extrastimulus was remarkably prolonged compared to at the basic cycle length (Figure 2A). Pacing from the site of the distal VOM also demonstrated decremental conduction along the VOM (Figure 2B). During CS distal pacing, radiofrequency (RF) energy (40 W) was delivered opposite the endocardial recording site of the VOM catheter (Figure 1B). A remarkable delay in LSPV potential with local VOM conduction block occurred after RF energy delivery (Figure 3). This phenomenon suggested that the presence of VOM conduction facilitated a dominant preferential conduction property such as a bypass tract within the VOM between the CS and LSPV.

Discussion

Histologic studies have indicated that the proximal portion of the VOM directly connects to the muscular sleeve of the CS, and the distal portion connects to the left atrial wall and LPVs, with wide variations.[4,5] The features of the connection may vary. Half of them are likely to include multiple connections, and one third are dual connections to the left atrial wall and LPVs.[6] In this case, we could directly record the epicardial site of the VOM, and the recorded potentials demonstrated multiple deflections and decremental conduction along the VOM, which may have predisposed to microreentry and macroreentry to maintain the atrial tachyarrhythmia. In this case, we could not totally deny the possibility that pacing captured both the VOM and atrial muscle; however, the magnified image (Figure 2) shows the decremental local conduction within the VOM. Furthermore, the detected potentials included multiple deflections along the VOM; therefore, the VOM properties might have included multiple connections to the atrium. Conduction

KEYWORDS Catheter ablation; Decremental conduction; Vein of Marshall
ABBREVIATIONS **AF** = atrial fibrillation; **CS** = coronary sinus; **LPV** = left pulmonary vein; **LSPV** = left superior pulmonary vein; **RF** = radiofrequency; **VOM** = vein of Marshall
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KEY TEACHING POINTS

- The epicardial site of vein of Marshall (VOM) potentials demonstrated multiple deflections and decremental conduction along the VOM, and the decremental conduction of the VOM has not been reported in previous studies. This unique property of the VOM may have predisposed to microreentry and macroreentry to maintain the atrial tachyarrhythmia.
- A high endocardial radiofrequency (RF) energy application to the VOM can successfully delineate the preferential conduction of the VOM. If VOM conduction is associated with increased subsequent arrhythmogenicity, then vigorous high RF energy application to the VOM, even from an endocardial site, may be effective in blocking the VOM conduction.
- The findings of this study can help us to understand the potential mechanism of reentrant atrial tachyarrhythmias, including the possibility of the Marshall bundle as a reentrant substrate after atrial fibrillation ablation.

delay may be caused by a complex fiber arrangement, abrupt changes in fiber directions, and anisotropic conduction.[7] In addition to these preexisting pathologic conditions, the anatomic boundaries and secondary slow conduction due to the extensive lines are likely to further promote circumstances that can maintain the development of a micro-reentrant and macroreentrant AT.[3,8–10]

To the best of our knowledge, decremental conduction of the VOM has not been reported. The findings of this study can help us to understand the potential mechanism of reentrant atrial tachyarrhythmias, including the possibility of the Marshall bundle as a reentrant substrate after AF ablation. In addition, endocardial application of high RF energy to the VOM just below the left inferior pulmonary vein could successfully delineate the preferential conduction of the VOM; this evidence also has not been previously reported. If a dominant preserved continuous and/or partial VOM is associated with increased subsequent arrhythmogenicity, then vigorous application of high RF energy to the VOM, even from an endocardial site, may be effective in blocking VOM conduction. If the VOM is located at sites that are out of reach of the endocardial RF energy, an alternative epicardial approach, such as chemical ablation, may be required to complete the ablation in such patients.

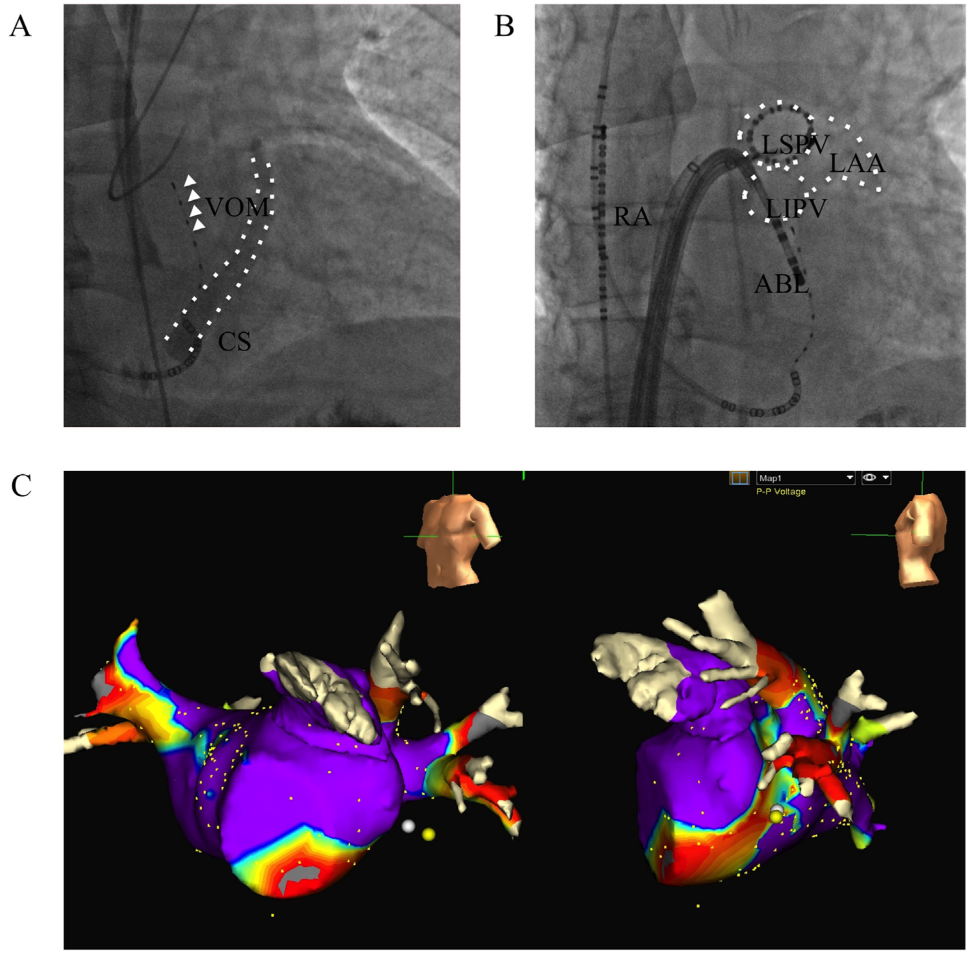

Figure 1 Coronary sinus (CS) venography and catheter location. The CS was visualized by contrast medium injected through the lumen of a 6Fr CS catheter in the left and right anterior oblique projections. **A:** The onset and course of the vein of Marshall (VOM) could be identified *(arrowheads)*. **B:** An adjustable 20-pole catheter (Inquiry Optima, St. Jude Medical) was used to map the left superior pulmonary vein (LSPV). A 4-mm irrigated-tip ablation catheter (St. Jude Medical) was positioned at a site opposite the endocardial site of the VOM. White dots indicate the course of (A) coronary sinus and the location of left pulmonary vein ostium and left appendage **C:** Three-dimensional image constructed using the EnSite NavX system. **Left:** Left anterior oblique view. **Right:** Left lateral view of the 3-dimensional images. The voltage map of the endocardium shows a low-voltage scar zone along the VOM (*gray* <0.1 mV, *purple* >0.5 mV). *White circle* indicates endocardial recording and ablation site. *Yellow circle* indicates epicardial distal electrode in the VOM. ABL = ablation catheter; LAA = left atrial appendage; LIPV = left inferior pulmonary vein; RA = right atrium.

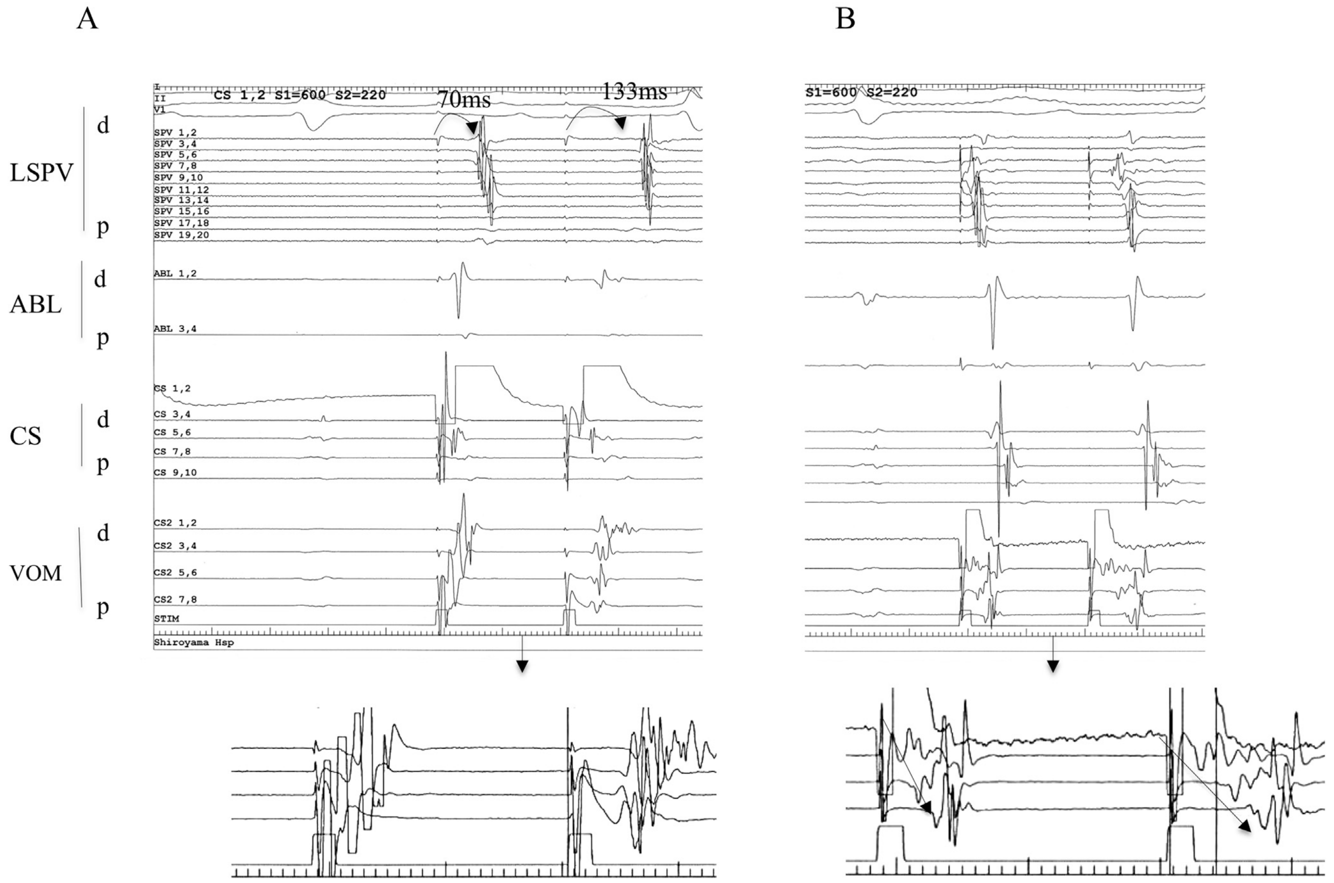

Figure 2 **A:** Pacing from the onset of the vein of Marshall (VOM) in the coronary sinus (CS). An extrastimulus (basic cycle length [BCL] 600 ms, S1S2 220 ms) revealed decremental conduction within the VOM. Conduction time between the CS and left superior pulmonary vein (LSPV) was significantly prolonged from 70 ms (BCL) to 133 ms (extrastimulus). The site of the main decremental conduction delay was mostly proximal (border of the CS and VOM) and distal VOM. The magnified image shows that decremental conduction is also observed along the VOM. The ablation catheter is located epicardially along the VOM and shows split double potentials during an extrastimulus mimicking VOM potentials. **B:** Pacing from the distal VOM Distal VOM pacing presumably captured only the VOM potential and demonstrated decremental conduction along the VOM and multiple deflections of the potentials along the VOM catheter (distal VOM to the CS), which might imply the presence of anisotropy and several connections to the atrium. The magnified image shows the first segment of a small potential reflecting the VOM, with the potential apparently representing decremental conduction within the VOM *(arrow).* Conduction between the distal VOM and LSPV was short, which reflects the presence of dominant rapid conduction along the left lateral ridge as the anterior barrier of the LSPV. ABL = ablation catheter; d = distal; p = proximal.

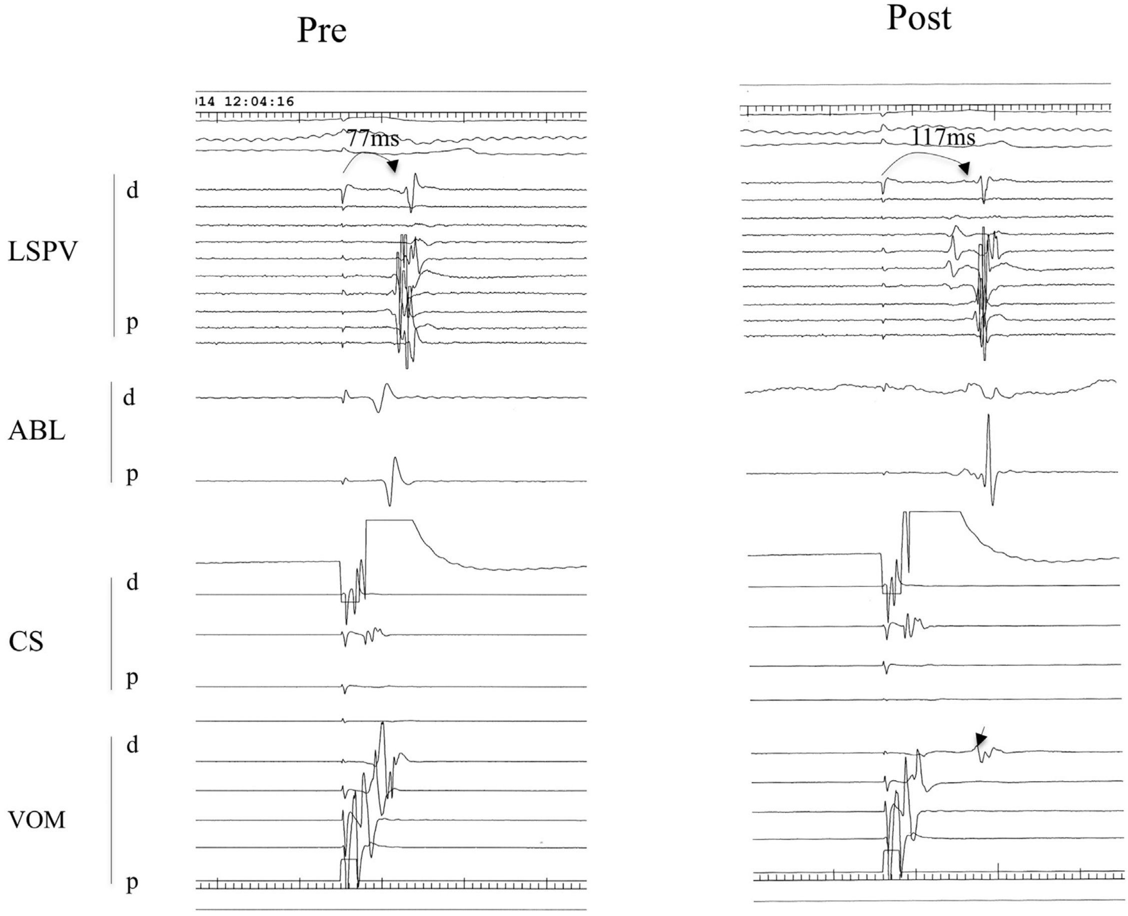

Figure 3 Conduction sequence before and after radiofrequency (RF) energy delivery during pacing from the onset of the vein of Marshall (VOM) in the coronary sinus (CS). Conduction time between the CS and left superior pulmonary vein (LSPV) suddenly prolonged during RF energy delivery (pre 77 ms, post 107 ms). The spilt double potentials of the distal VOM *(arrow)* electrogram imply local conduction block after RF delivery. ABL = ablation catheter; d = distal; p = proximal.

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