Utility of the novel microcatheter in left ventricular summit arrhythmias with a tortuous anterior interventricular vein

Yuichiro Sagawa, MD,* Yasuteru Yamauchi, MD,* Yasuyuki Ohgino, MD,† Manabu Kurabayashi, MD,* Masahiko Goya, MD,‡ Tetsuo Sasano, MD‡

From the *Department of Cardiology, Japan Red Cross Yokohama City Bay Hospital, Yokohama City, Japan, †Department of Cardiology, Keiyu Hospital, Yokohama City, Japan, and ‡Department of Cardiovascular Medicine, Tokyo Medical and Dental University, Tokyo, Japan.

Introduction
The left ventricular (LV) summit is a predominant site for idiopathic ventricular arrhythmias (VAs). Catheter ablation of VAs originating from the LV summit remains challenging because these arrhythmias are usually originating from the subepicardial or intramural foci, making it difficult to identify the origin accurately owing to inaccessibility.1–3 Komatsu and colleagues4 reported that mapping of the LV summit using a 2F microcatheter (1.3 mm electrode with 5 mm inter-electrode spacing; EPstar Fixed 2F; Japan Lifeline, Tokyo, Japan) introduced into the anterior interventricular vein (AIV) could help identify the precise site of VAs in the LV summit. However, in some patients, a microcatheter cannot be introduced into the distal portion of the AIV owing to a tortuous vein. Additionally, there is a risk of cardiac tamponade owing to vessel injury or perforation during forced insertion. Moreover, the inability to place the microcatheter distal to the AIV may prevent accurate identification of the VA origin.

We present a case in which a novel 2.7F microcatheter (AIV catheter with over-the-wire type [0.65 mm electrode with 5 mm inter-electrode spacing; EPstar Fixed AIV; Japan Lifeline, Tokyo, Japan] that became available in Japan from November 2020) (Figure 1) helped identify the reentrant circuits of ventricular tachycardia (VT) originating from the LV summit with a tortuous AIV.

**KEY TEACHING POINTS**

- Mapping the anterior interventricular vein (AIV) may help understand the origin or reentrant circuit of the left ventricular (LV)-summit ventricular arrhythmias.
- In some cases, introducing the mapping catheter into the AIV is abandoned because the AIV is tortuous or the angle of the great cardiac vein–to-AIV transition is steep.
- The novel over-the-wire-type 2.7F microcatheter could be safely introduced beyond the tortuous AIV following the preceding guidewire and helped identify the reentrant circuits of ventricular tachycardia originating from the LV summit with a tortuous AIV.

**Case report**
A 63-year-old woman who experienced palpitations and dizziness was transferred to her previous hospital. The 12-lead electrocardiogram demonstrated a VT with a cycle length of 263 ms. In addition, the QRS morphology exhibited a right bundle branch block configuration with an inferior axis (Figure 2). The patient was barely conscious and was in cardiac shock with a blood pressure of 70 mm Hg. She underwent emergency cardioversion, and VT was converted to sinus rhythm. Emergent coronary angiography showed no stenosis of the coronary artery, and cardiac magnetic resonance imaging did not show a late gadolinium enhancement in the left ventricle. Transsthoracic echocardiography showed good cardiac function without any abnormalities; therefore, the VT was considered idiopathic. She was referred to our hospital and was admitted for radiofrequency catheter ablation following the difficulty in preventing VT by medication.
After informed consent was obtained, the patient underwent an electrophysiological study and ablation. Premature ventricular contractions (PVCs) frequently occurred at the start of the examination, and the QRS morphology of PVCs remained the same as that of clinical VT (Figure 2). The PVC was suspected of having originated from the LV summit because the QRS morphology exhibited a right bundle branch block configuration and an inferior axis with a maximum deflection index of >0.55. Therefore, epicardial mapping of the coronary venous system was needed. A 6F decapolar catheter with an inner lumen (5 mm interelectrode spacing; EPstar Fixed CS; Japan Lifeline, Tokyo, Japan) was inserted from the internal jugular vein and placed in the coronary sinus. Retrograde venography was performed to visualize AIV through the inner lumen of the decapolar catheter in the coronary sinus, and it showed that the AIV was winding vertically (Figure 2). A novel over-the-wire-type 2.7F microcatheter with an inner lumen (0.65 mm electrode with 5 mm interelectrode spacing; EPstar Fixed AIV; Japan Lifeline, Tokyo, Japan) (Figure 1) was used because it seemed difficult to safely introduce the microcatheter into the distal part of the AIV. The novel microcatheter can be inserted into the inner lumen of the 6F decapolar catheter (EPstar Fixed CS), and the inner lumen of the microcatheter allows the insertion of a 0.014-inch guidewire. A 0.014-inch JOKER PV guidewire (Japan Lifeline, Tokyo, Japan) was advanced through the inner lumen of the microcatheter into the distal part of the AIV, and the microcatheter was placed safely in the mid to distal part of the AIV following the guidewire (Figure 2). The ventricular activation recorded at the middle AIV preceded the PVC-QRS onset by 40 ms, and pacing from the middle AIV showed an excellent pace map (Figure 3). The anatomical opposite site of the middle AIV was the LV endocardial aortomitral continuity (AMC), and the endocardial mapping of the AMC was performed using a PentaRay catheter (Biosense Webster, Diamond Bar, CA) with the CARTO mapping system (Biosense Webster). The ventricular activation recorded at the AMC preceded the PVC-QRS onset by 30 ms. Clinical VT was induced by extrastimulus pacing from the right ventricular apex. Constant fusion was demonstrated by entrainment pacing from the right ventricular apex during VT, and progressive fusion was observed when the pacing cycle length was shortened. Mid-diastolic potentials (MDP) were recorded at the PentaRay catheter placed on the AMC during VT (Figure 3). When entrainment pacing was performed at the AMC where MDP was observed, concealed fusion was demonstrated. Based on these findings, we diagnosed this tachycardia as a macroreentrant VT with a central common pathway at the AMC. The propagation of the tachycardia on the activation map is shown by a propagation map (Supplemental Video). Moreover, since no MDP was observed on the microcatheter placed in the AIV, the pace map from the AIV during sinus rhythm matches the QRS morphology of clinical VT, and the ventricular activation recorded at the AIV was preceding that of the AMC by 10 ms during the mapping of PVC with the same QRS morphology as that of clinical VT (Figure 3), we have concluded that the clinical VT was a “3-dimensional reentrant VT” with an exit site on the AIV (epicardial site) and part of a central pathway on the AMC (endocardial site) (Supplemental Figure 1). Ablation was initiated using an irrigated catheter (ThermoCool SmartTouch Surround Flow, Biosense Webster) at the site where the MDP was recorded. The initial application slowed down the VT, and the second application near the initial ablation site terminated the VT in less than 3 seconds (Supplemental Figure 2). Additional burns were applied to all sites where the MDP was recorded. All procedures were
promptly completed without complications. VT was not induced by any ventricular stimulus during isoproterenol infusion. After the ablation, the patient was followed up without any antiarrhythmic drugs and remained free from VT recurrence at 3 months of follow-up.

Discussion
The LV summit is one of the predominant sites of idiopathic VAs. VAs originating from the LV summit pose a challenge to ablation because identifying their origin accurately and catheter manipulation to reach the LV summit can be difficult. In recent years, detailed mapping from the great cardiac vein (GCV) to the AIV has been reported as useful for identifying VA origin or determining the target sites of ablation, and might increase the success rate of ablation for LV-summit VAs. For a detailed mapping of GCV-AIV, it is a prerequisite that the microcatheter can be successfully introduced into the AIV. However, in some cases, the microcatheter cannot be introduced into the distal AIV owing to the steep angle at the GCV-AIV transition or the tortuous AIV. Tavares and colleagues have reported that approximately 30% (16/52 patients) of the cases examined for the GCV-AIV angle had a steep angle (>100°), and forcefully inserting a microcatheter into a vessel with a steep angle may cause pericardial effusion or cardiac tamponade owing to venous injury. The key to a successful ablation of VAs originating from the LV summit is the safe introduction of a

Figure 2 Twelve-lead electrocardiogram showing clinical ventricular tachycardia (VT) with a cycle length of 263 ms and QRS morphology exhibiting a right bundle branch block configuration with an inferior axis (upper left) and a premature ventricular contraction with almost the same QRS morphology as clinical VT (upper right). In the lower-left fluoroscopic image, the coronary venography by retrograde injection through the inner lumen of the decapolar catheter placed in the coronary sinus demonstrates a tortuous anterior interventricular vein (AIV). The lower-right fluoroscopic image demonstrates that the microcatheter following the 0.014-inch guidewire is introduced beyond the meandering site to the distal part of the AIV, and the meandering site of the AIV is straightened by the microcatheter. RAO = right anterior oblique.
microcatheter into the AIV. The novel over-the-wire-type 2.7F microcatheter used in this case follows the preceding guidewire, and despite the steep angle at the GCV-AIV transition, the microcatheter can be safely introduced when the guidewire is advanced into the distal AIV. In this case, the microcatheter could be introduced beyond the tortuous AIV without venous injury or perforation, and the exit site of the VT was estimated by pace mapping from the AIV. Furthermore, by mapping the anatomical opposite site (AMC) of the AIV, which was the earliest activated site, the diastolic pathway of the VT circuit could be identified promptly. Consequently, the ablation target site could be determined rapidly, and the procedure was completed efficiently without complications.

Whereas idiopathic VT originating from the LV outflow tract is mainly caused by focal mechanisms, ie, triggered activity or abnormal automaticity, reentrant VT arises in a structurally abnormal heart owing to the presence of scar tissue.8–9 This case is extremely valuable because the patient had idiopathic reentrant VT with a 3-dimensional tachycardia circuit with a diastolic pathway in the AMC despite showing good cardiac function without any abnormalities in echocardiography and the absence of late gadolinium enhancement in the right and left ventricles, including the outflow tract.

**Conclusion**
The novel microcatheter preceded by the guidewire can help us safely perform mapping of AIV in cases of LV-summit VAs with tortuous AIV or steep GCV-AIV angle. Furthermore, mapping AIV may facilitate understanding of the origin or reentrant circuit of LV-summit VAs.

**Appendix**
**Supplementary data**
Supplementary data associated with this article can be found in the online version at https://doi.org/10.1016/j.hrcr.2022.02.010.

**References**
1. Santangeli P, Marchlinski FE, Zado ES, et al. Percutaneous epicardial ablation of ventricular arrhythmias arising from the left ventricular summit: outcomes and electrocardiogram correlates of success. Circ Arrhythm Electrophysiol 2015; 8:337–343.
2. Enriquez A, Malavassi F, Saenz LC, et al. How to map and ablate left ventricular summit arrhythmias. Heart Rhythm 2017;14:141–148.
3. Nagashima K, Choi EK, Lin KY, et al. Ventricular arrhythmias near the distal great cardiac vein: challenging arrhythmia for ablation. Circ Arrhythm Electrophysiol 2014;7:906–912.

4. Komatsu Y, Nomura A, Shinoda Y, et al. Idiopathic ventricular arrhythmias originating from the vicinity of the communicating vein of cardiac venous systems at the left ventricular summit. Circ Arrhythm Electrophysiol 2018;11:e005386.

5. Daniels DV, Lu YY, Morton JB, et al. Idiopathic epicardial left ventricular tachycardia originating remote from the sinus of Valsalva: electrophysiological characteristics, catheter ablation, and identification from the 12-lead electrocardiogram. Circulation 2006;113:1659–1666.

6. Yamada T, Kumar V, Yoshida N, Doppalapudi H. Eccentric activation patterns in the left ventricular outflow tract during idiopathic ventricular arrhythmias originating from the left ventricular summit: a pitfall for predicting the sites of ventricular arrhythmia origins. Circ Arrhythm Electrophysiol 2019;12:e007419.

7. Tavares L, Fuentes S, Lador A, et al. Venous anatomy of the left ventricular summit: therapeutic implications for ethanol infusion. Heart Rhythm 2021;18:1557–1565.

8. Kim RJ, Iwai S, Markowitz SM, Shah BK, Stein KM, Lerman BB. Clinical and electrophysiological spectrum of idiopathic ventricular outflow tract arrhythmias. J Am Coll Cardiol 2007;49:2035–2043.

9. Nakano E, Harada T, Aonuma K, et al. Identification of unusual reentry circuit sites of nonischemic ventricular outflow tract tachycardia. J Cardiovasc Electrophysiol 2012;23:179–187.