

Catheter ablation for verapamil-sensitive fascicular ventricular tachycardia guided by precise mapping using a multi-spline duodecapolar catheter with small electrodes and close spacings



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Introduction

The Purkinje fiber network serves as an arrhythmogenic substrate for idiopathic ventricular tachycardia.¹ While catheter ablation can be an effective therapy for Purkinje-related arrhythmias, detection of the critical site by mapping the Purkinje fiber network is required to successfully treat them. We report a case of verapamil-sensitive left-posterior fascicular ventricular tachycardia (F-VT) successfully treated with catheter ablation guided by a precise mapping using a PentaRay catheter.

Case report

A 17-year-old man visited our hospital owing to palpitation and faintness. An electrocardiogram exhibited wide QRS tachycardia (cycle length = 270 ms) with right bundle branch block and left axis deviation (Figure 1). Intravenous administration of verapamil 1.25 mg terminated this tachycardia with deceleration of heart rate. The tachycardia was thought to be verapamil-sensitive left-posterior F-VT. Several months later, he visited our hospital again, owing to the recurrent tachycardia. We thus decided to undertake catheter ablation.

In the electrophysiologic study, we placed a 5F quadripolar catheter (Inquiry C1, St. Jude Medical, Saint Paul, MN) at the His bundle site and a 5F decapolar catheter (Inquiry M-SC, St. Jude Medical) in the coronary sinus via the left femoral vein, and a mapping and ablation catheter (FlexAbility, St. Jude Medical) at the right ventricular septum via the right femoral vein. The tachycardia was induced by a programmed stimulus from the right ventricle

KEY TEACHING POINTS

- While catheter ablation can be an effective therapy for Purkinje-related arrhythmias, including fascicular ventricular tachycardia (F-VT), detection of the critical site by mapping the Purkinje fiber network is required to successfully treat them.
- Mid-to-late diastolic potentials during F-VT, the common target of catheter ablation, that could not be recorded by linear catheters were reproducibly recorded using a PentaRay catheter.
- The PentaRay catheter is useful and sometimes essential in mapping and ablation for Purkinje-related arrhythmias, including F-VT, which requires a precise mapping of the Purkinje fiber network.

and the atrioventricular dissociation was confirmed. The HV intervals during sinus rhythm and F-VT were 57 ms and -30 ms, respectively. We performed entrainment pacing to the F-VT, and a progressive fusion in response to the right ventricular septum pacing in variable pacing cycle lengths was observed. Then, we placed a linear duodecapolar catheter with 5F, 1-mm tip and 3-mm center-to-center spaced electrodes (Livewire, St. Jude Medical) in the left ventricle (LV) longitudinally via a retrograde aortic approach. We carefully mapped the posteroseptal wall of the LV by manipulating the steerable linear duodecapolar catheter. We recorded high-frequency, presystolic potentials (P2), which represent the left-posterior fascicular potentials, conducting retrogradely during the F-VT along the linear catheter. However, mid-to-late diastolic potentials (P1) during F-VT preceding P2 potentials and LV muscular potentials, the common target of catheter ablation for F-VT, could not be recorded. Thus, we tried to map precisely around the site where the earliest P2 and

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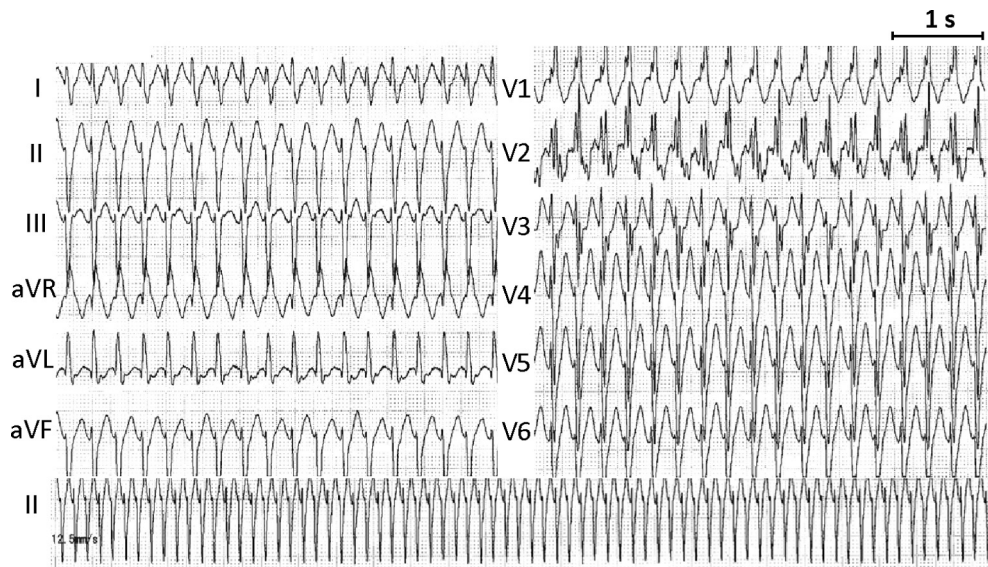


Figure 1 A 12-lead electrocardiogram showing left-posterior fascicular ventricular tachycardia.

the subsequent ventricular potential during the F-VT were recorded (electrodes 5/6 of the linear catheter), using a duodecapolar catheter that has 5 soft radiating splines with 3F, 1-mm tip and 2-mm center-to-center spaced electrodes (PentaRay, Biosense Webster, Diamond Bar, CA) via a transeptal approach with a deflectable sheath (Agilis, St. Jude Medical) (Figure 2A). The PentaRay catheter and the EnSite NavX System (St. Jude Medical) were bypassed by the patient interface unit of the CARTO System (Biosense Webster). By using the PentaRay catheter, we could reproducibly record P1 in the posteroseptal region of the LV. We tagged the sites with P1 in white on the 3-dimensional mapping system (EnSite Velocity System, St. Jude Medical). A discrete P1 with subsequent P2 were recorded stably around the earliest P2 site (electrodes 1–4 of the PentaRay catheter in Figure 2A–C), and we tagged such sites in orange (Figure 2B). The P1 and P2 activation map revealed that the F-VT propagated downward in the septal wall of the LV to the site where P1 met P2 (the orange dots), and turned upward. Then, we positioned the irrigated mapping and ablation catheter with 7F, 4-mm tip and 3.5-mm center-to-center spaced electrodes to the site of the larger orange dot with a transeptal approach, but the P1 could not be recorded (Figure 3). We started an application of radiofrequency energy (35 W) to the site of the larger orange dot, and the F-VT was terminated after prolongation of the tachycardia cycle length and was never induced by isoproterenol infusion and programmed stimuli. After the session, F-VT did not recur during 6 months of follow-up.

Discussion

We here report a case of verapamil-sensitive F-VT successfully treated with catheter ablation guided by a precise mapping of P1 using a PentaRay catheter. A century ago,

Tawara² reported Purkinje fibers as a conduction system of the ventricle. Recently, there have been a number of reports on so-called “Purkinje-related arrhythmias,” including F-VT.^{1,3} Although P1 is the common target of catheter ablation for F-VT, P1 cannot be recorded in up to one third of cases using linear catheters.⁴ There may be some anatomical limitations in such cases: P1 fiber may not be long or parallel to the long axis of the LV, which makes it difficult to record P1 with linear catheters. In addition, linear catheters may not touch along the Purkinje fiber network with sufficient contact to record P1 owing to endocardial trabeculations. We previously reported advantages of using a PentaRay catheter to detect discrete Purkinje potentials for mapping of Purkinje-related premature ventricular contractions and triggered ventricular fibrillation.⁵ The advantages of the PentaRay catheter for mapping the Purkinje fiber network are as follows: First, the small electrodes and close spacings allow the recording of fine potentials that might be missed with larger electrodes.⁶ Second, the 5 radiating flexible splines of the PentaRay catheter can crawl into the 3-dimensional network structure and facilitate precise mapping along the Purkinje fiber network. In this case, with the use of the PentaRay catheter, we could reproducibly record discrete P1 that could not be recorded with the linear catheters (Figure 3C). Interestingly, the PentaRay catheter also recorded several continuous fractionated potentials in the early to mid-diastolic phase of F-VT, some of which might represent an upper part of the F-VT circuit. Further investigation is warranted.

Conclusion

The PentaRay catheter is useful and sometimes essential in mapping and ablation for Purkinje-related arrhythmias, including F-VT, which requires a precise mapping of the Purkinje fiber network.

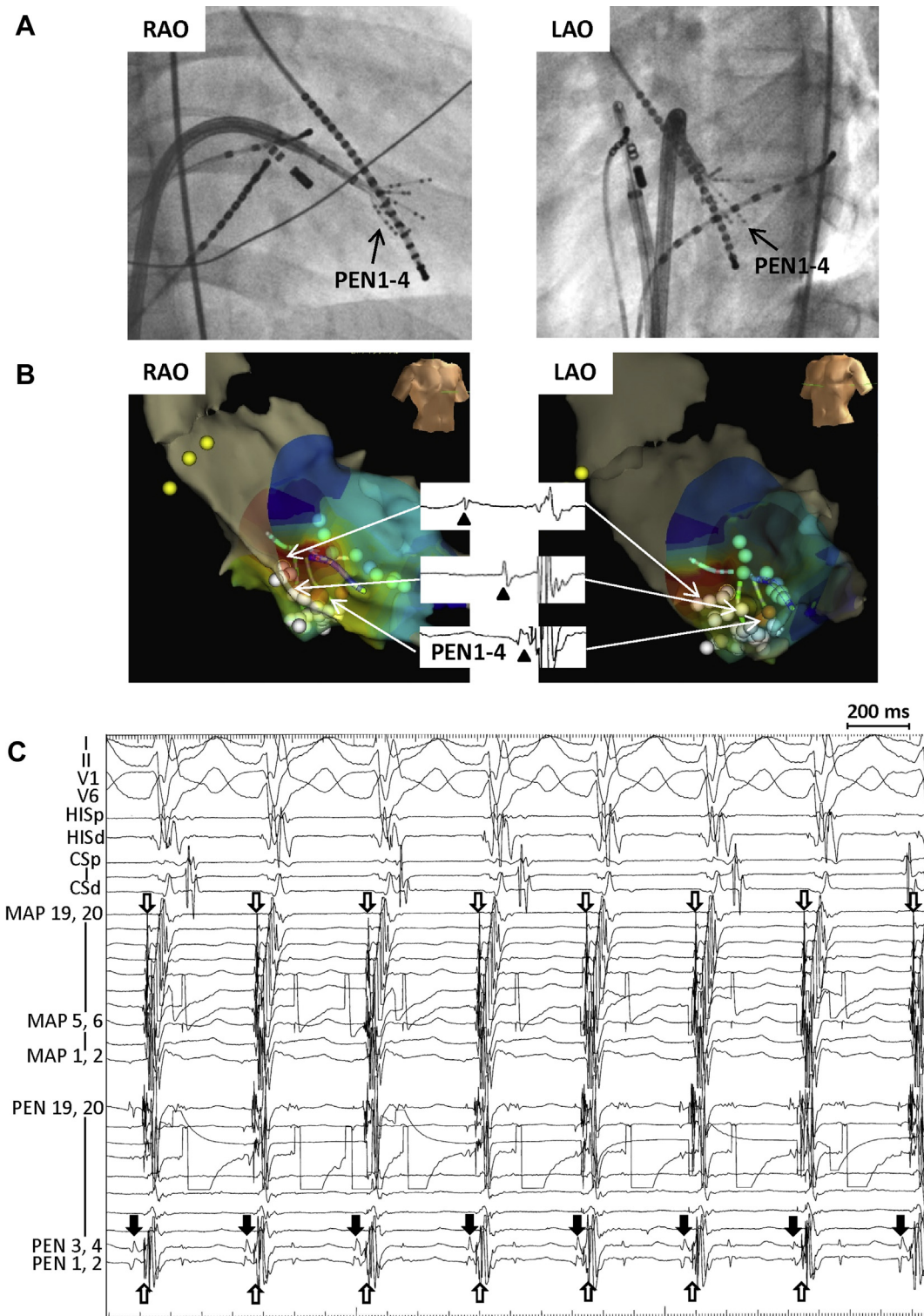


Figure 2 **A:** Right anterior oblique (RAO) and left anterior oblique (LAO) views of fluoroscopy during mapping of the left ventricle. **B:** A 3-dimensional map in the left ventricle (EnSite Velocity system). The yellow dots indicate the His bundle site. The *aqua-lined dots* indicate the site where the left-posterior fascicle potentials (P2) were recorded and the *blue dots* indicate the earliest P2 site. The *white dots* indicate the sites where the mid-to-late diastolic potentials (P1) were recorded. The *orange dots* indicate the sites where discrete P1 and subsequent P2 were recorded stably (PEN 1–4). Several local electrograms of P1 recorded with a PentaRay catheter (*black arrowheads*) were also shown in the map. We delivered radiofrequency energy to the site of the *larger orange dot*. **C:** Intracardiac electrogram during fascicular ventricular tachycardia. Earliest P2 and the subsequent ventricular potential were recorded at MAP 5, 6, and they conducted upward along the linear catheter (*white downward arrows*). P1, which could not be recorded with the linear catheter, were reproducibly recorded with the PentaRay catheter. P1 (*black arrows*) and subsequent P2 (*white upward arrows*) around the earliest P2 site were recorded stably at PEN 1, 2 and 3, 4. Square waves at MAP 7, 8 and PEN 13, 14 are artifacts.

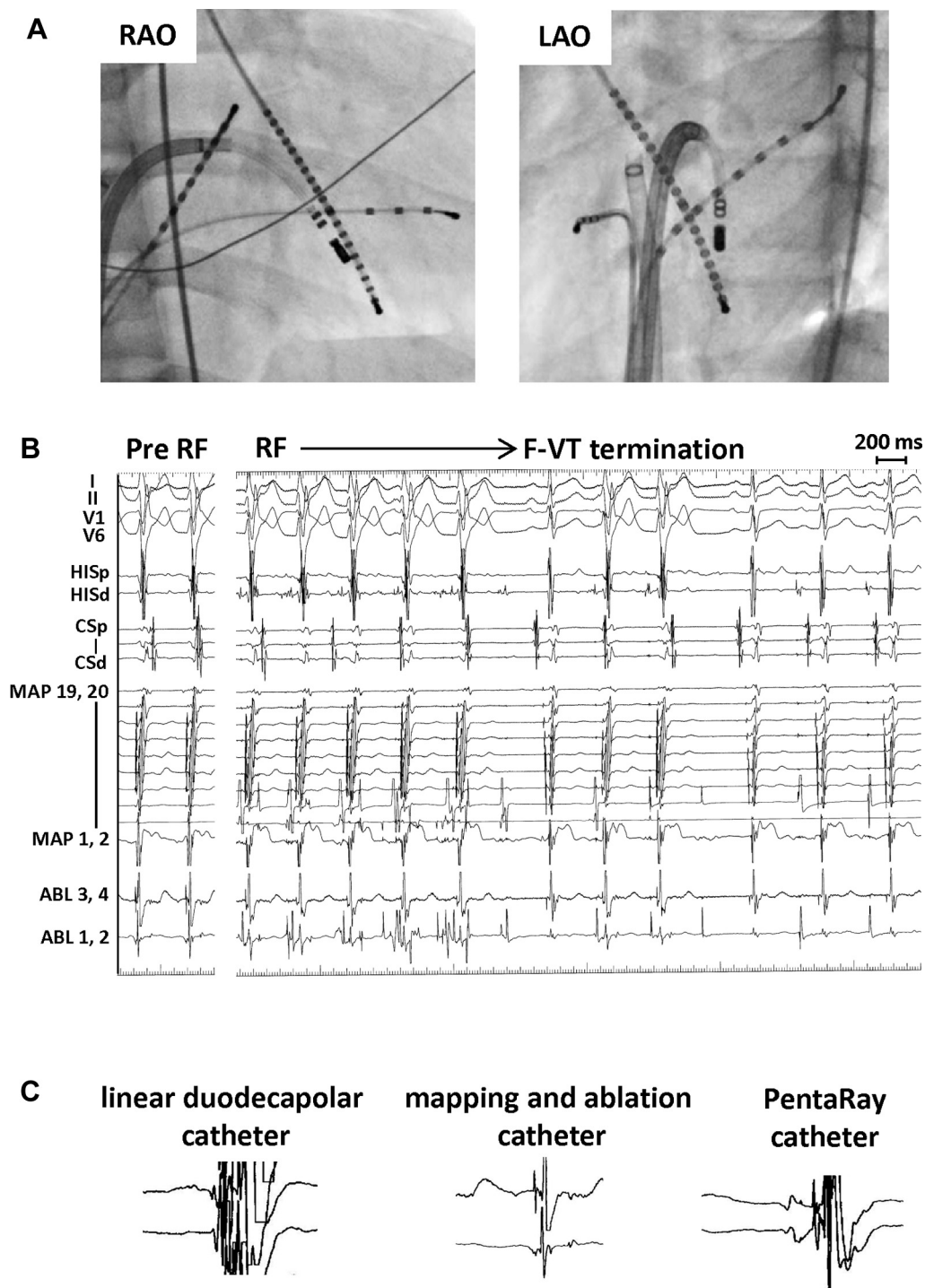


Figure 3 **A:** Right anterior oblique (RAO) and left anterior oblique (LAO) views of fluoroscopy during application of radiofrequency (RF) energy. **B:** The large-tip mapping and ablation catheter could not record the late diastolic potentials during fascicular ventricular tachycardia (F-VT). After an application of RF energy was started, ventricular tachycardia terminated following prolongation of the tachycardia cycle length. **C:** Magnification of the comparison of the local electrograms recorded at the targeted PI site using the linear duodecapolar catheter, the mapping and ablation catheter, and the PentaRay catheter, respectively, before an application of radiofrequency energy.

References

1. Nogami A. Purkinje-related arrhythmias part I: monomorphic ventricular tachycardias. *Pacing Clin Electrophysiol* 2011;34:624–650.
2. Tawara S. *Das Reizleitungssystem des Säugetierherzens - Eine anatomisch - pathologische Studie über das Atrioventrikulärbündel und die Purkinjeschen Fäden.* Jena, Germany: Verlag von Gustav Fischer; 1906.
3. Kapa S, Gaba P, DeSimone CV, Asirvatham SJ. Fascicular ventricular arrhythmias: pathophysiologic mechanisms, anatomical constructs, and advances in approaches to management. *Circ Arrhythm Electrophysiol* 2017; 10:e002476.
4. Liu Q, Shehata M, Jiang R, Yu L, Chen S, Zhu J, Ehdaie A, Sovari AA, Cingolani E, Chugh SS, Jiang C, Wang X. Macroreentrant loop in ventricular

- tachycardia from the left posterior fascicle: new implications for mapping and ablation. *Circ Arrhythm Electrophysiol* 2016;9:e004272.
5. Takase S, Mukai Y, Ohe K, Chishaki A, Tashiro H, Tsutsui H. Usefulness of a multi-spline duodecapolar catheter with smaller electrodes and closer spacings for mapping and ablation of Purkinje-related premature ventricular contraction and triggered ventricular fibrillation. *HeartRhythm Case Rep* 2017;3:255–258.
 6. Anter E, Tschabrunn CM, Josephson ME. High-resolution mapping of scar-related atrial arrhythmias using smaller electrodes with closer interelectrode spacing. *Circ Arrhythm Electrophysiol* 2015;8:537–545.