Electroanatomic visualization of reentrant circuit of left fascicular ventricular tachycardia guiding a fluoroless ablation

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Introduction

Left fascicular ventricular tachycardia (LFVT) affects young adults (aged 15–40 years) with structurally normal hearts. In 90% of cases LFVT originates from the left posterior fascicle and has a right bundle brunch block pattern with left axis deviation (and in rare cases with right axis deviation). LFVT is often responsive to calcium channel blocker administration.[1–3] In some cases LFVT may be incessant and may cause a reversible tachycardia-related cardiomyopathy.

Catheter ablation is an effective treatment with a high success rate and is recommended as first-line treatment in symptomatic patients by current guidelines from the European Society of Cardiology (class of recommendation I, level of evidence B), with the recommended ablation site at abnormal Purkinje tissue with diastolic activity during ventricular tachycardia (VT).[4,5] However, the exact nature of the reentrant circuit in LFVT is still debated.[6–9] The use of an electroanatomic mapping (EAM) system with the latest technologies available can provide the opportunity to better visualize the reentrant circuit generating the onset of the LFVT, in order to guide the ablation procedure and deliver the best care for the patient. We present a case report of a young woman with LFVT undergoing EAM and effective transcatheter ablation.

KEY TEACHING POINTS

- Endocardial 3D mapping of the left ventricle and the Purkinje fibers during left fascicular ventricular tachycardia (LFVT) demonstrated the possibility to record a diastolic potential (P1) representing the proximal-to-distal activation of the diastolic part of the reentrant circuit (anterograde limb) and a second presystolic Purkinje potential (P2), preceding the QRS onset, representing the retrograde activation of the left posterior fascicle (retrograde limb of the VT circuit).
- The 3D system propagation map visually demonstrated that the reentrant circuit of LFVT involves a large part of the left ventricular conduction system in the interventricular septum and is not limited to the area surrounding the earliest endocardial ventricular activation.
- Optimal visualization of the reentrant circuit during LFVT can guide the physician to identify the real mechanism causing the arrhythmia, so as to better identify the ablation site, increasing efficacy and safety.

Case report

We show the case of a 26-year-old woman with history of palpitations since the age of 12 years.

Electrocardiogram (ECG) at rest was normal, while during palpitations ECG showed a wide QRS tachycardia, 190 beats per minute, with right bundle branch block morphology and left axis deviation (Figure 1). Despite this, tachycardia was responsive to verapamil intravenous administration (dose of 0.05 mg/kg of intravenous verapamil infused over 30 minutes); this drug was ineffective during the follow-up (oral dose of 180 mg once daily). The patient underwent a transthoracic echocardiography and cardiac magnetic resonance, which excluded any sign of structural heart disease. In light of the patient's not tolerating chronic beta-blocker therapy (nadolol 20 mg once daily, discontinued owing to bradycardia and hypotension) and the frequent recurrences, she was referred to our center for electrophysiological study and transcatheter ablation. After the first recording of LFVT, the patient spontaneously interrupted noncompetitive sport activity, thought to be a potential trigger of arrhythmia recurrences.

KEYWORDS Left fascicular ventricular tachycardia (LFVT); Radiofrequency catheter ablation; Purkinje potential; 3D mapping system; Electroanatomic mapping system

(Heart Rhythm Case Reports 2023;9:745–748)

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https://doi.org/10.1016/j.hrcr.2023.07.020

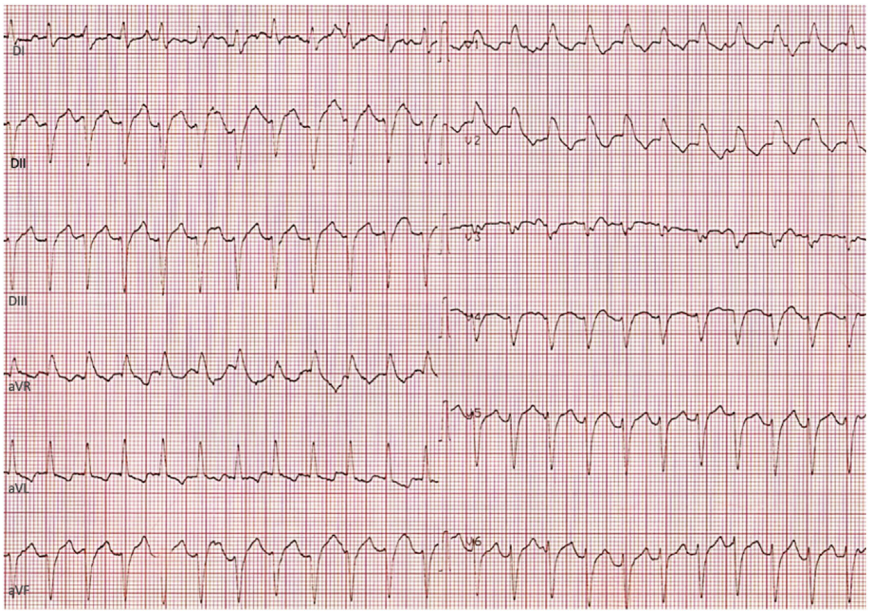

Figure 1 Twelve-lead electrocardiogram of the spontaneous clinical ventricular tachycardia, showing wide QRS tachycardia (QRS 120 ms) at 150 beats/min with right bundle branch block and left anterior fascicle block morphology.

The electrophysiology procedure was performed using a fluoroless approach by Carto 3 mapping system (Biosense Webster, Irvine, CA). A standard quadripolar catheter was placed in the right ventricle via the right femoral vein. Through a retrograde transaortic approach, a high-density mapping catheter (PentaRay; Biosense Webster) and a 3.5-mm-tip irrigated ablation catheter (ThermoCool SmartTouch; Biosense Webster) were inserted alternatively into the left ventricle. Clinical VT was easily inducible (using incremental programmed ventricular stimulation with double extrastimuli with 400 ms cycle and by mechanical stimulation during EAM; Figure 2A), and consequently endocardial high-resolution activation mapping was performed during VT (Figure 2B).

The activation map demonstrated the presence of 2 distinct potentials in the septal area, belonging to the posterior fascicle. We distinguished a diastolic potential (P1) representing the proximal-to-distal activation of the diastolic part of the reentrant circuit, ending at the level of the exit site of the ventricular activation. This corresponds to the anterograde limb of the VT circuit, inside the Purkinje fiber network of the left posterior fascicle. A second presystolic Purkinje potential (P2) was also present: it was a spike deflection of small amplitude following P1 and preceding the QRS onset, representing the retrograde activation of the left posterior fascicle (retrograde limb of the VT circuit; Figure 3).

Along the mid–interventricular septum, from the base to the apex, P1 progressively approaches P2, until they join and fuse with the QRS at the site of the earliest endocardial ventricular activation, corresponding to the VT exit site at the inferoseptal apex. The 3D system propagation map considering both Purkinje fibers and endocardial activation visually demonstrated that the reentrant circuit of this tachycardia was confined to the Purkinje network with a distal exit in the normal myocardium at the inferior part of the interventricular septum. In fact, after the systolic endocardial activation the wavefront reentered the left posterior fascicle in the basal septum where the earliest P1 potential was recorded (Supplemental Video 1).

Effective ablation was performed at the end of the diastolic path before the exit site, where P1 still preceded P2. Radiofrequency (RF) energy was delivered with an irrigated catheter in a power-controlled mode with a maximum power of 40 W and a pulse duration of 60 seconds (6 ablation lesions, total RF time of 5 minutes and 20 seconds; Supplemental Figure 1). At the end of the procedure and after 30 minutes, both at baseline and during isoprenaline infusion, the tachycardia was no longer inducible. No complications were observed after the procedure, and the patient was discharged the day after. Follow-up visits were scheduled at 3 months, 6 months, and 1 year after the procedure, including 12-lead ECG and 24-hours ECG Holter recording. The patient did not experience recurrence of any documented arrhythmia and/or palpitation symptoms, maintaining stable sinus rhythm without use of any antiarrhythmic drug during the follow-up. After 3 months from the procedure, she restarted noncompetitive sports, without any symptoms.

Discussion

LFVT generally affects young adults (aged 15–40 years), mainly males (60%–80%), without structural heart disease. The most common presentations are paroxysmal episodes of palpitations and dizziness, typically triggered by exercise or emotional stress. Syncope and sudden death are very rare and tachycardiomyopathy has been described in patients with persistent tachycardia, usually reversible after successful ablation. Transcatheter ablation represents the curative

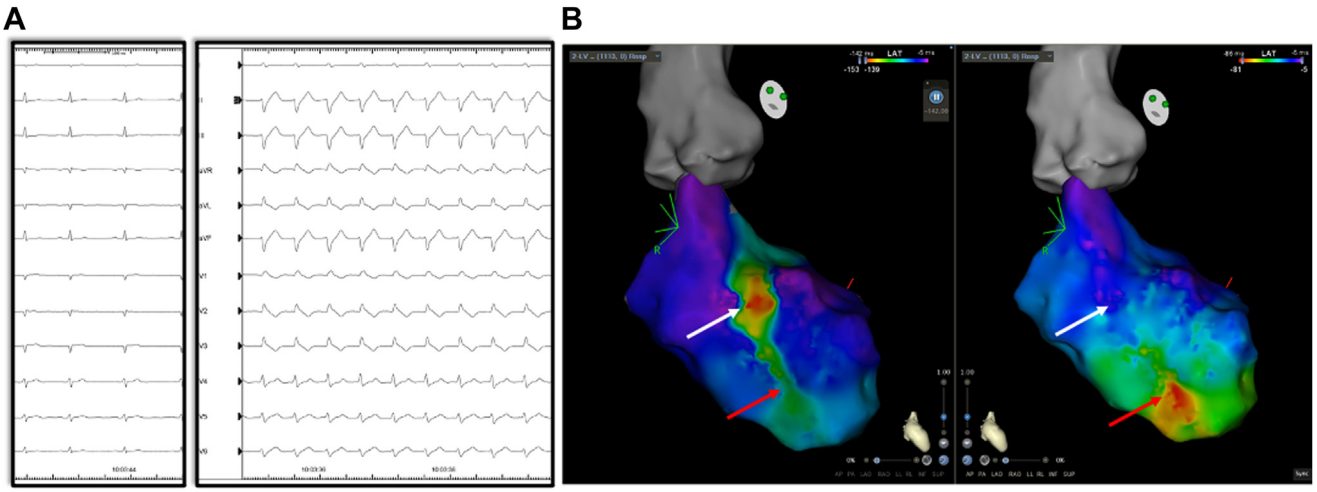

Figure 2 **A:** Rest 12-lead electrocardiogram (ECG) with sinus rhythm and ECG recording of the induced ventricular tachycardia during electrophysiological study (the same ECG leads in the right and left subpanels are displayed). **B:** Three-dimensional activation map of the left ventricle during clinical ventricular tachycardia, showing the entrance site (anterobasal septum, *white arrow*) and exit site (posteroapical septum, *red arrow*) of the reentrant circuit.

treatment of this arrhythmia, but the exact nature of the reentrant circuit in LFVT is still debated.[6–9]

Ouyang and colleagues[6] published a prospective study on LV mapping in 9 patients with idiopathic left ventricular (LV) tachycardia. The study illustrated images of a complete endocardial LV map during idiopathic LV tachycardia demonstrating the reentrant circuit of the arrhythmia, with the propagation of the impulse in the LV endocardium, starting from the LV apex spreading out in a caudocranial direction from the lower to the higher part of the LV septum.[6] Differently,

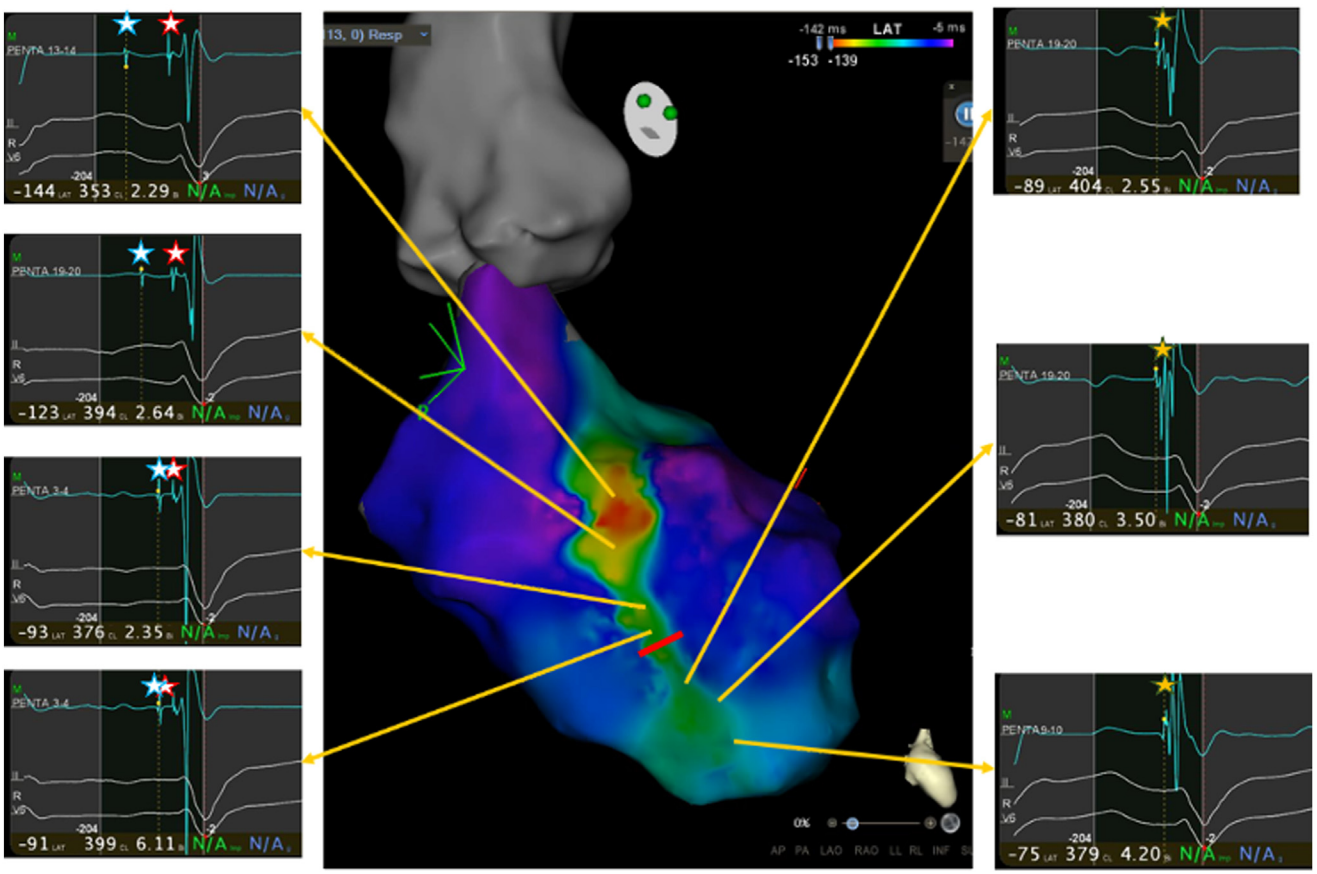

Figure 3 Electroendocardial recordings during ventricular tachycardia. Through the high-density mapping catheter (PentaRay; Biosense Webster) a diastolic Purkinje potential (P1; light blue star) could be recorded at a small area in the middle of the left ventricular septum, with a proximal (basal)-to-distal (apical) activation, toward the presystolic Purkinje potential (P2; red star). Red line indicates radiofrequency ablation line.

in our case report, using newest EAM modalities, we were able to map the left ventricle in a more detailed fashion, unveiling the real reentrant circuit (as seen in Figure 3 and Supplemental Video 1). In fact, the LFVT exit point (first endocardial activation) is the same both in our case report and in the cases presented by Ouyang and colleagues, but in our case report we showed that the anterograde slow pathway of the circuit is confined to the posterior fascicle and that the Purkinje fibers activation have a craniocaudal direction (different from the findings by Ouyang and colleagues). Our findings could be explained taking into account not only the LV endocardial activation, but also the activation of the LV conduction system. The EAM, performed with a more recent EAM system, allowed us to start the analysis from the earliest LV activation, led by the conduction system potentials (Purkinje fibers). The activation spreads from the earliest potential in the mid portion of the posterior fascicle running along it and reaching the exit point at the inferoapical portion of the left ventricle. From the exit point the LV activation then showed a caudocranial direction activation, similar to the report by Ouyang and colleagues.[6] The main difference of our report from the paper of Ouyang and colleagues seems to be the different interpretation of the EAM, in our case focusing on the LV conduction system and in the case of Ouyang and colleagues focusing only on the global LV activation. In our opinion, the accurate and high-quality EAM representations during LFVT of our report were able to illuminate the real reentrant circuit of this arrhythmia in a very finely detailed fashion, located in the Purkinje network of the left posterior fascicle, with the entrance site at the basal-superior region of the left interventricular septum and the exit site at the inferoapical region of the left interventricular septum, as shown in Supplemental Video 1.

It has already been demonstrated that the site of successful catheter ablation of verapamil-sensitive VT is in the midapical septal area where both P1 and P2 are recorded during VT. In the present report, we have shown in a highly detailed fashion the 3D propagation map, giving for the first time a visual representation of the reentrant circuit confined to the Purkinje network of the posterior fascicle, supporting the hypothesis of the presence of a reentrant circuit sustaining LFVT.[10,11] Entrainment technique, however, was not performed, and this may represent a limitation to the arrhythmia mechanism diagnosis. Our case also confirms the great value of the high-resolution mapping system to find critical diastolic Purkinje potentials in the septal area as well as around the papillary muscles, thus guiding the effective ablation.[12,13] Moreover, the use of a very precise 3D electroanatomic mapping system allowed to perform a fluoroless procedure.

Conclusion

Three-dimensional EAM during LFVT visually showed the reentrant circuit confined to the Purkinje network, supporting the hypothesis of reentrant circuit as the underlying mechanism of this tachycardia. The 3D mapping helped identify the precise site where the successful fluoroless RF ablation was performed.

Acknowledgments

The authors thank Andrea Lamanna (biomedical engineer, Biosense Webster) for the technical support of the 3D electroanatomical mapping during the procedure and the development of figures and videos for the present case report.

Funding Sources: None.

Disclosures: None related to this article for any author.

Appendix

Supplementary Data

Supplementary data associated with this article can be found in the online version at https://doi.org/10.1016/j.hrcr.2023.07.020.

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