

# Two apparently remote types of ventricular tachycardia from a single right bundle branch focal source



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## Introduction

Different morphologies of focal right ventricular (RV) tachycardia displaying left or right axis deviation of the QRS complex imply 2 distinct arrhythmic sources and raise suspicion of underlying structural heart disease.<sup>1</sup> A single RV idiopathic focal source in the distal right bundle branch (RBB) giving rise to 2 apparently distinct ventricular tachycardia (VT) types with the opposite QRS axes due to alternating exits from the source has never been reported.

## Case report

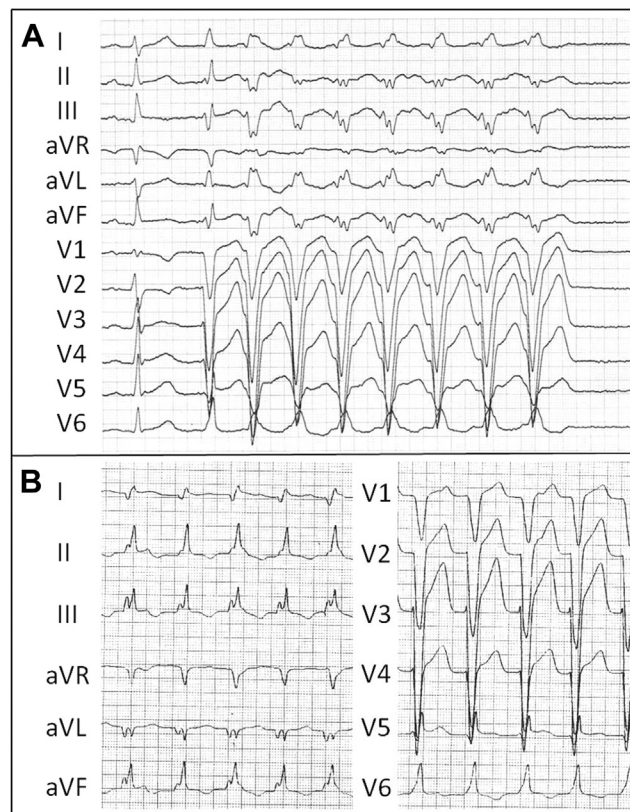
We report a case of a 23-year-old man referred to catheter ablation for a 3-year history of incessant repetitive episodes of nonsustained or sustained VT symptomatic with fatigue, occasional presyncope, and an isolated syncope at the early stage of arrhythmia occurrence. Two types of VT with left bundle branch block (LBBB) morphology and either left or right deviation of the QRS axis recurred despite treatment with beta blocker, verapamil, flecainide, and amiodarone. Ambulatory Holter electrocardiography monitoring did not reveal any polymorphic VT. No structural changes of the heart or voltage abnormalities of the right ventricle were present on echocardiography and cardiac magnetic resonance, or on subsequent electroanatomic mapping (see below). At first sight, the alternating VTs with the QRS complex positive either in leads I and aVL (type 1 VT) or in leads II, III, and aVF (type 2 VT) suggested 2 distinct arrhythmias originating at remote inferior wall and outflow tract of the right ventricle, respectively (Figure 1).

At the electrophysiology study, there were no abnormalities of atrioventricular conduction (AH interval 95 ms, HV interval 50 ms, Wenckebach point of the atrioventricular node at 120 beats per minute, and no retrograde ventriculoatrial conduction) except incomplete right bundle branch block (RBBB) with the QRS complex width of 85 ms.

**KEYWORDS** Ventricular tachycardia; Focal; Right bundle branch; Moderator band; Catheter ablation (Heart Rhythm Case Reports 2017;3:264–267)

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Frequent ventricular premature contractions (VPCs) and nonsustained VTs dominantly with the type 2 VT morphology occurred spontaneously or were induced by pacing or isoproterenol. Electroanatomic activation mapping was performed during the type 2 VT or VPCs, and the earliest activation was located around the septal insertion of the moderator band (MB), as confirmed by intracardiac echocardiography (Figure 2). Subsequently, favorable pace mapping for the type 2 VT was obtained directly above the MB insertion, while matching pace mapping for the type 1 VT was found beneath the MB insertion toward anterior free wall of the right ventricle (Figure 2). Open-irrigated (30 mL/min of heparinized 0.9% saline) radiofrequency energy (Stockert generator, Biosense Webster, Diamond

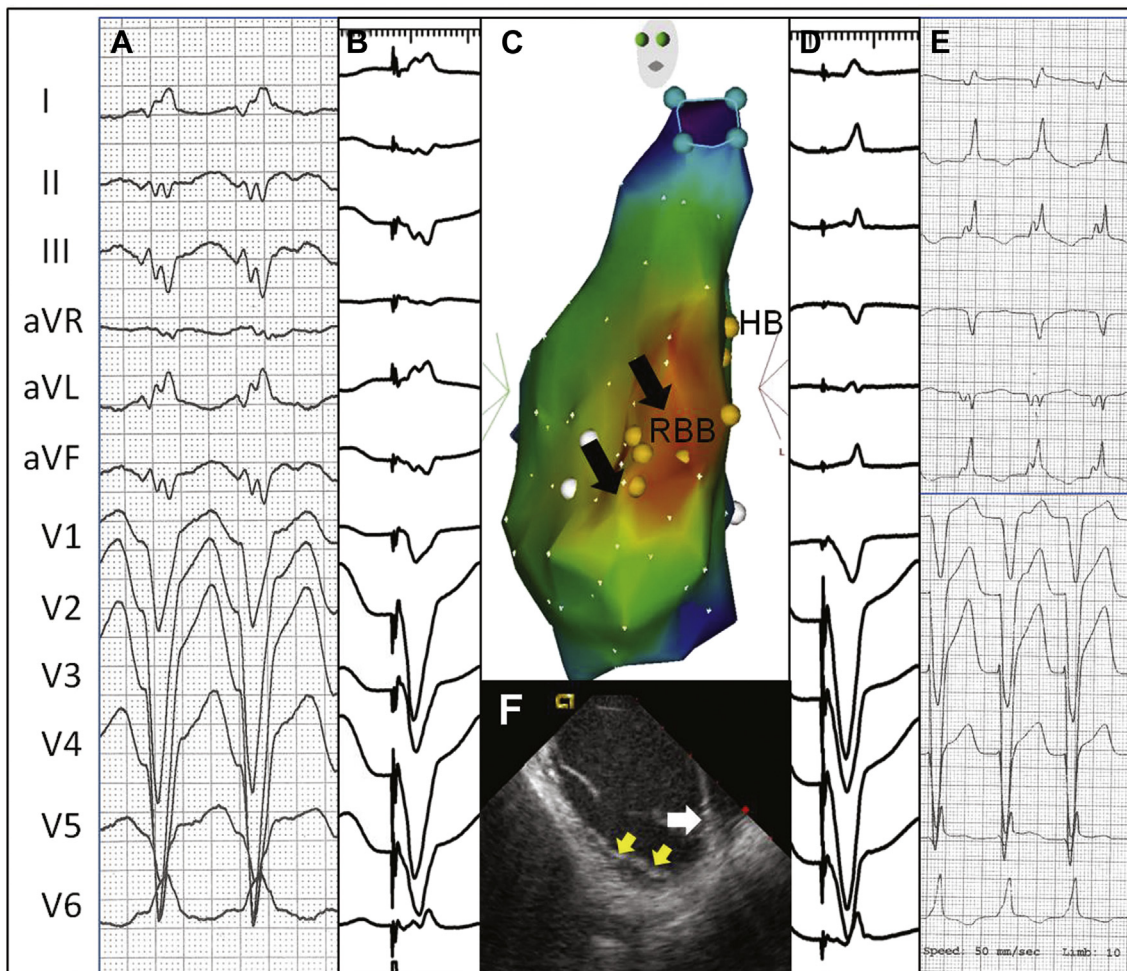


**Figure 1** A: Type 1 and B: type 2 of ventricular tachycardia on 12-lead surface electrocardiogram.

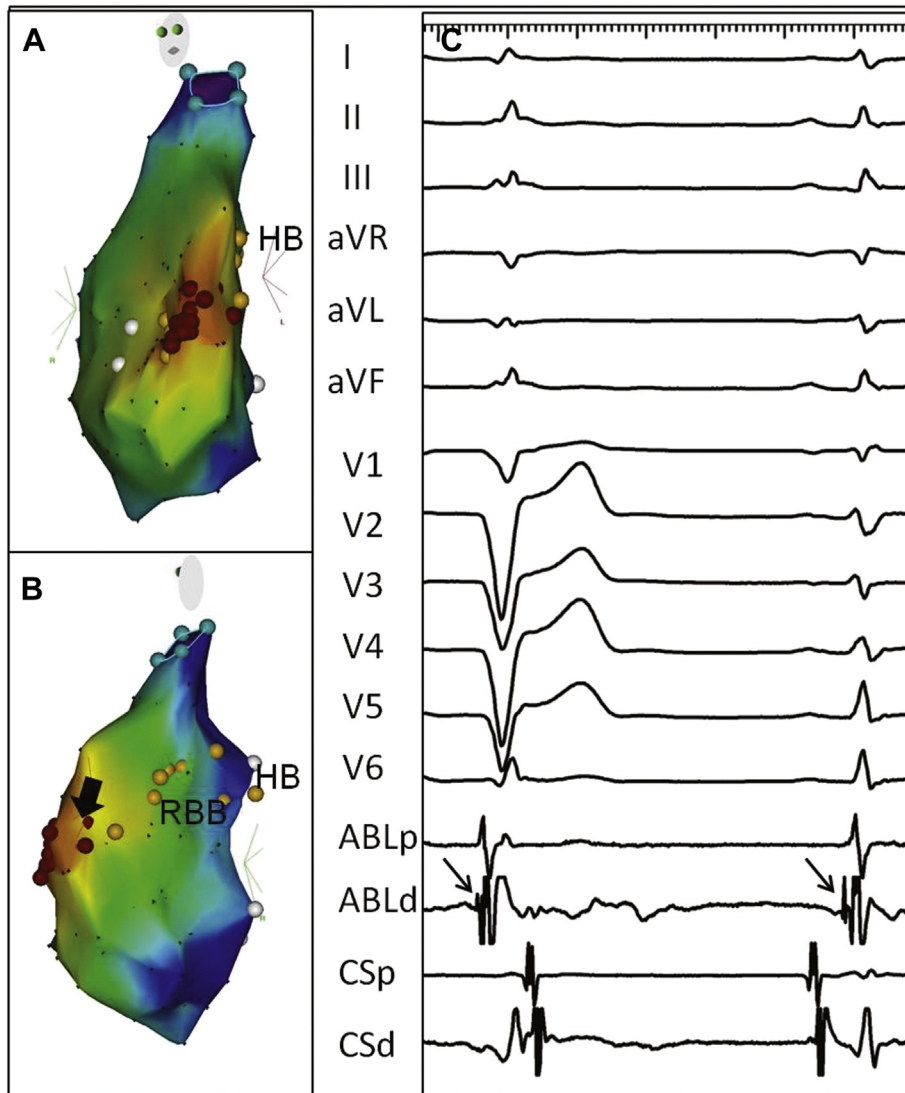
**KEY TEACHING POINTS**

- Alternating types of ventricular tachycardia (VT) with left bundle branch block pattern and opposite QRS axes at first sight suggest 2 distinct VT sources due to right ventricular (RV) cardiomyopathy.
- In this case, a single idiopathic focus originating in the distal right bundle branch close to the septal insertion of the moderator band (MB) and mimicking 2 VTs by alternating exits from the source was confirmed by electroanatomic mapping, pace mapping, and successful ablation.
- The MB anatomy and insertion at the medial RV septum likely facilitated alternating inferior and superior activation spreads from the VT source, resulting in entirely opposite vectors of ventricular activation.

Bar, CA) was applied through ablation catheter (NaviStar ThermoCool, Biosense Webster, Diamond Bar, CA) inserted via an 8F long sheath (Mullins fixed curve, Fast Cath Transseptal Sheath, St. Jude Medical Inc., St. Paul, MN) with temperature and power limited to 42°C and 50 W. Initial application of radiofrequency current beneath the MB eliminated the type 1 VT and PVCs. Extension of localized radiofrequency lesion upwards (total of 11 applications and 14 minutes of radiofrequency energy delivery) failed to ablate the type 2 VT, which was eventually abolished at the septum above and proximal to the MB insertion where clear RBB potential was recorded at a 54 mm distance from the His bundle potential (Figure 3). Successful radiofrequency energy application was associated with progression of incomplete into intermittent rate-dependent complete RBBB (QRS complex width of 120 ms). At the end of the procedure, no ventricular arrhythmia (VA) was induced with programmed and incremental ventricular pacing and isoproterenol infusion, and no VA recurred during the 12-month follow-up.



**Figure 2** Electroanatomic activation mapping of the right ventricle in left anterior oblique view (C) during type 2 ventricular tachycardia (VT) (E) showed the VT origin in the distal right bundle branch (RBB) region close to the septal insertion of moderator band (the earliest right ventricular activation is coded in red color; the course of His bundle [HB] and RBB is marked by yellow dots). Pace mapping directly beneath (C, lower arrow) and above (C, upper arrow) the moderator band insertion produced favorable match between the paced QRS complex (B, D) and the QRS complex of type 1 (A) or type 2 (E) VT, respectively. F: The course of the moderator band (yellow arrows) and ablation catheter (white arrows) on intracardiac echocardiography.



**Figure 3** Ventricular ectopy was targeted by stepwise ablation starting anteriorly beneath the septal insertion of moderator band (**A** – left oblique view of right ventricular electroanatomic map) and was eventually abolished at the distal end of right bundle branch (RBB) (marked by *arrow*, **B** – left lateral view of right ventricular electroanatomic map) above and proximal to the septal insertion of moderator band at a site displaying small RBB potential (*arrows*) preceding the local ventricular electrogram during ectopic and sinus beat (first and second beat, **C**). The earliest local ventricular potential recorded by the distal bipole of ablation catheter (ABLd) preceded the onset of surface QRS complex by 23 ms (**C**). ABLp = recording from the proximal bipole of ablation catheter; CSp, CSd = recordings from the proximal and distal bipoles of the 10-pole catheter placed in the coronary sinus. Other abbreviations and explanations as in [Figure 2](#).

## Discussion

A single focal source manifesting as VA with alternating QRS morphologies has been described in other cardiac locations<sup>2</sup> and specifically in the left ventricular papillary muscles.<sup>3</sup> These thick myocardial structures comprising complex separated myocardial strands on the basal and apical sides facilitate anisotropic conduction and alternating impulse propagation from deeper layers in different directions; however, entirely opposite QRS axes were not usual.<sup>3</sup>

This is the first report of a single focal source related to the distal RBB close to the septal MB insertion that manifested as 2 VT types with the opposite QRS axes and mimicked 2 distinct VTs originating from remote RV inferior and outflow tract regions. A single VT source was confirmed by activation mapping, pace mapping, and successful ablation. Double

exit from this source was likely related to the MB (septomarginal trabecula), which as a shortcut across the chamber carries part of the RBB to the base of the anterior papillary muscle. Spatial dissociation between the superior and inferior spread of ectopic activation might relate to the MB thickness (mean  $4.5 \pm 1.8$  mm) and its anatomic insertion at the medial level of the RV septum at roughly one-half to two-thirds of the distance from the tricuspid valve to the RV apex.<sup>4</sup> Alternating exits beneath or above the MB insertion might be facilitated by slight shifts of the ectopic impulse origin within the Purkinje fibers inward-downward the MB or backward-upward the septum, and/or by anisotropic conduction, which is supported by findings of fat infiltration<sup>5</sup> or elements of endocardium that in the form of streaks penetrate the muscular tissue of the MB and its septal insertion.<sup>6</sup>

Distinction of a pure MB-related VT source from the distal RBB source close to the septal MB insertion may be vague and rather arbitrary, since the MB encompasses distal RBB Purkinje fibers, and sharp Purkinje system potential was observed at successful ablation sites in both VA types.<sup>7,8</sup> In addition, both VAs may exhibit the same electrocardiogram pattern with LBBB morphology, late precordial transition in leads V5-V6, rapid downstroke of the QRS complex in the precordial leads, and left superior frontal plane axis (similar to the type 1 VT in our case).<sup>7,8</sup> Although we did not compare electroanatomic activation maps acquired during both VT types, several features support a rather distal RBB source. They include clinical manifestation as idioventricular rhythm or VT with chronotropic variability accelerating by physical exercise, stress of isoproterenol infusion (whereas previously described MB-related sources rather manifested as VPCs inducing ventricular fibrillation), spontaneous presence of proximal exit giving rise to the type 2 VT with right QRS axis deviation (which was not described in the MB-related VAs), and complete abolition of all VAs by septal ablation above/proximal to the MB insertion at a site with distal RBB potential accompanied by ablation-induced progression of incomplete into complete RBBB.<sup>7,8</sup> Furthermore, the MB length on intracardiac echocardiography (Figure 3) in relation to the sites of favorable pace mapping and the extent and location of the radiofrequency lesion did not support abolition of a pure MB-related source by targeting septal and free-wall MB insertions.<sup>7</sup>

Change of exits from a distal RBBB-related VT source was previously described; however, it was not spontaneous and, unlike in our case, it resulted from prior ablation and manifested as a change of LBBB morphology of the initial VT into RBBB morphology of the recurrent VT (ie, change of activation spread across the septum toward the left ventricle).<sup>8</sup>

Idiopathic RV arrhythmia originating in the distal RBB or MB is a rare entity of unknown underlying reasons, although increased automaticity is the likely mechanism.<sup>7-13</sup> The clinical manifestation suggesting focal VT does not exclude, for example, arrhythmogenic RV cardiomyopathy.<sup>1</sup> In this case, confounding multiple VT morphologies were not related to obvious RV structural disease, and catheter ablation appeared the optimal treatment. Yet, the risk of the development of tachycardia-induced cardiomyopathy<sup>8,11-13</sup> or MB-related VPC-induced idiopathic ventricular fibrillation<sup>7</sup> emphasizes

the need for a case-by-case assessment of sudden cardiac death risk and close monitoring before and after ablation in patients with similar arrhythmia.

## Conclusion

Alternating activation spread from a single idiopathic source in the distal RBB Purkinje fibers upwards above or downwards beneath the MB septal insertion can mimic 2 distinct VT types from apparently distant RV sources. Successful catheter ablation of this source is feasible.

## References

1. Phillips B, Madhavan S, James C, Tichnell C, Murray B, Needleman M, Bhonsale A, Nazarian S, Laurita KR, Calkins H, Tandri H. High prevalence of catecholamine-facilitated focal ventricular tachycardia in patients with arrhythmogenic right ventricular dysplasia/cardiomyopathy. *Circ Arrhythm Electrophysiol* 2013;6:160-166.
2. Ma J, Wu K, Wang Y, Ma C, Chu J. Premature ventricular contractions with two QRS morphologies originate from one focus in great cardiac vein. *Heart Rhythm Case Rep* 2016;2:204-207.
3. Yamada T, Doppalapudi H, McElderry HT, et al. Electrocardiographic and electrophysiological characteristics in idiopathic ventricular arrhythmias originating from the papillary muscles in the left ventricle: relevance for catheter ablation. *Circ Arrhythm Electrophysiol* 2010;3:324-331.
4. Loukas M, Klaassen Z, Tubbs RS, Derderian T, Paling D, Chow D, Patel S, Anderson RH. Anatomical observations of the moderator band. *Clin Anat* 2010;23:443-450.
5. Uehara M, Takaoka H, Ozawa K, Kobayashi Y, Funabashi N. Clinical significance of fat infiltration in the moderator band and right ventricular myocardium in multislice CT, and its association with abnormal conduction seen in electrocardiogram. *Int J Cardiol* 2013;168:352-356.
6. Kosinski A, Grzybiak M, Nowinski J, Kedziora K, Kuta W, Dajbrowska-Kugacka A, Lewicka E, Raczak G, Kozlowski D. Morphological remarks regarding the structure of conduction system in the right ventricle. *Kardiologia Pol* 2012;70:472-476.
7. Sadek MM, Benhavan D, Sureddi R, et al. Idiopathic ventricular arrhythmias originating from the moderator band: electrocardiographic characteristics and treatment by catheter ablation. *Heart Rhythm* 2015;12:67-75.
8. Chen M, Gu K, Yang B, Chen H, Ju W, Zhang F, Yang G, Li M, Lu X, Cao K, Ouyang F. Idiopathic accelerated idioventricular rhythm or ventricular tachycardia originating from the right bundle branch: unusual type of ventricular arrhythmia. *Circ Arrhythm Electrophysiol* 2014;7:1159-1167.
9. Lau EW, Marshall HJ, Griffith MJ. Fascicular tachycardia and parasystole of right bundle branch origin. *Heart Rhythm* 2005;2:994-996.
10. Moniotte S, Triedman JK, Cecchin F. Successful cryoablation of ventricular tachycardia arising from the proximal right bundle branch in a child. *Heart Rhythm* 2008;5:142-144.
11. Seethala S, Mezu UL, Némec J. Incessant tachycardia with borderline QRS duration, short HV interval, and left ventricular dysfunction: what is the mechanism? *Heart Rhythm* 2013;10:1234-1236.
12. Wu L, Tian H, Wang F, Liang X, Chen G. Successful ablation of incessant idiopathic right ventricular tachycardia arising from unusual sites in children. *Cardiol Young* 2016;26:764-771.
13. Liu A, Gardner MJ, Basta MN, Sapp JL. Tachycardia with a left bundle branch block morphology in a patient with arrhythmogenic right ventricular cardiomyopathy: what is the mechanism? *Heart Rhythm* 2008;5:895-896.