Morphology-algorithm match in an ICD patient with atrial fibrillation

Recurrent symptomatic regular tachycardia

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Summary

We present a case of bundle-branch reentry ventricular tachycardia (BBR-VT) in a patient with underlying dilated cardiomyopathy. This is a rare form of VT using a reentry circuit typically consisting of the right bundle branch serving as the antegrade limb and the left bundle branch as the retrograde limb. It often occurs in patients with advanced conduction system disease, like in our case, a complete left bundle-branch block (LBBB). In BBR-VT there is often an unchanged QRS pattern compared with sinus rhythm which makes diagnosis challenging. In our case, even the automated morphology algorithm of the patient's implantable cardioverter-defibrillator, which compared the EGM morphology during normal rhythm and tachycardia, failed to correctly identify the ventricular origin of the patient's tachycardia. Catheter ablation of the right bundle branch is the preferred treatment of BBR-VT and resolved the problem in our patient.

Key words: bundle branch reentry VT; implantable defibrillator; detection enhancement algorithm

Case presentation

A 53-year-old patient with an implantable cardioverter-defibrillator (ICD) presented with recurrent symptomatic tachycardia episodes. He had undergone primary prophylactic VVI-ICD implantation for dilated cardiomyopathy with severely reduced left ventricular ejection fraction (LVEF) 5 years before. His resting ECG at presentation showed persistent atrial fibrillation (AF) and a preexisting left bundle branch block. According to the device's morphology algorithm (Boston Scientific Teligen 100, Rhythm ID algorithm), the tachycardia episodes showed an intracardiac electrogram (EGM) morphology match (RID+) with the baseline EGM. Some of the episodes were successfully terminated by anti-tachycardia pacing (ATP) (fig. 1), while others were accelerated to a faster ventricular tachycardia (VT) by ATP and subsequently terminated by ICD shocks. The presence of relevant coronary heart disease was ruled out by coronary angiography. Beta-blocker therapy was increased and loading with amiodarone was performed, both of which failed to prevent further tachycardia episodes and ICD shocks.

What is the tachycardia mechanism and how should it be managed?

Differentiation between supraventricular tachycardia (SVT) and VT was the first important step in this patient. The tracing in figure 1 shows the EGMs during a tachycardia episode with the nearfield bipolar EGM (recorded from the electrode tip) displayed on top and the farfield EGM (recorded from the right ventricular [RV] coil to the can) displayed on the bottom. The tracing in the upper panel shows an irregular ventricular activation during atrial fibrillation in the first part. Then a regular tachycardia starts with a sudden onset. Once 8/10 beats are below the VT threshold, a ventricular episode is declared ("V-Epsd" at the beginning of the middle panel). After additional 5 seconds of ongoing VT (programmed detection time), the criteria for a durable ventricular episode are met ("V-Dur"). However, the "Rhythm-ID" algorithm is active in this ICD. It is used in Boston Scientific ICDs for automated comparison of the EGM morphology during normal rhythm (persistent atrial fibrillation in our patient) and tachycardia for enhanced discrimination between SVT and VT. As shown in the second part of the middle panel, the "Rhythm ID" algorithm indicates a morphology match (RID+), and as a consequence, VT therapy is withheld. In the lower part of the tracing, the ninth beat no longer fulfills the beat-to-beat morphology match criteria (RID–). Accordingly, ATP is appropriately applied and terminates the tachycardia. Following tachycardia termination, AF is still the underlying rhythm.

The termination of a regular tachycardia by ATP in the context of ongoing AF speaks strongly in favour of VT. On the other hand, no change in EGM morphology during the tachycardia, as indicated by the Rhythm-ID morphology match, clearly speaks in favour of SVT. However, the occurrence of regular SVTs such as atrioventricular-nodal reentry tachycardia (AVNRT) or orthodromic atrioventricular-reentrant tachycardia (AVRT) during ongoing atrial fibrillation is very unlikely, despite some rare case reports suggesting the opposite [1]. Another potential differential diagnosis would be an atrial flutter with 1:1 conduction under treatment with amiodarone. But given the fact that

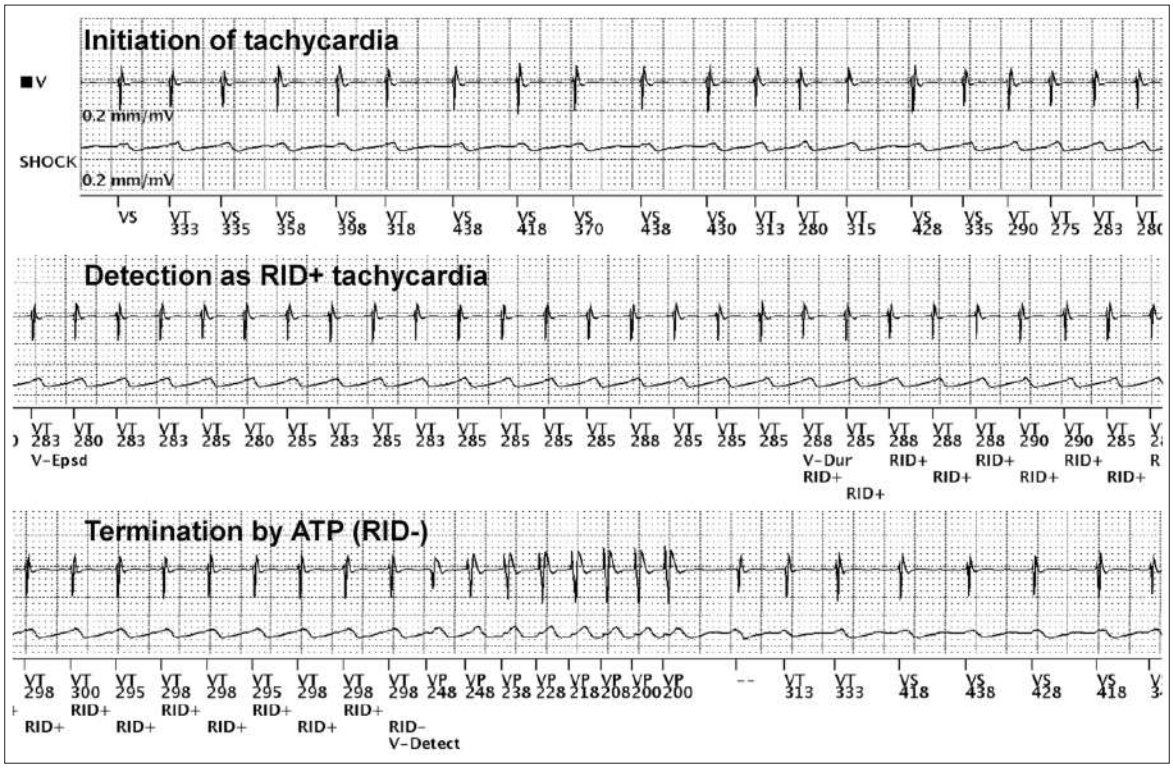

Figure 1: Intracardiac electrogram (EGM) of a tachycardia episode successfully terminated by antitachycardia pacing (ATP). RID+ = morphology match with the baseline EGM; RID– = no such match; V-Dur = durable ventricular episode; V-Epsd = ventricular episode.

some of the episodes were terminated by ATP this is very unlikely. Alternatively, VTs with an EGM morphology similar or identical to the regular supraventricular rhythm are rare. They may occur due to a idiopathic or scar-related septal ventricular tachycardia exit that allows early access to the normal conduction system. Another possibility is bundle branch reentry VT (BBR-VT), a rare form of VT in patients with preexisting conduction system diseases and typically left bundle-branch block (LBBB), in which the QRS and EGM during tachycardia match the QRS and EGM during normal rhythm with LBBB.

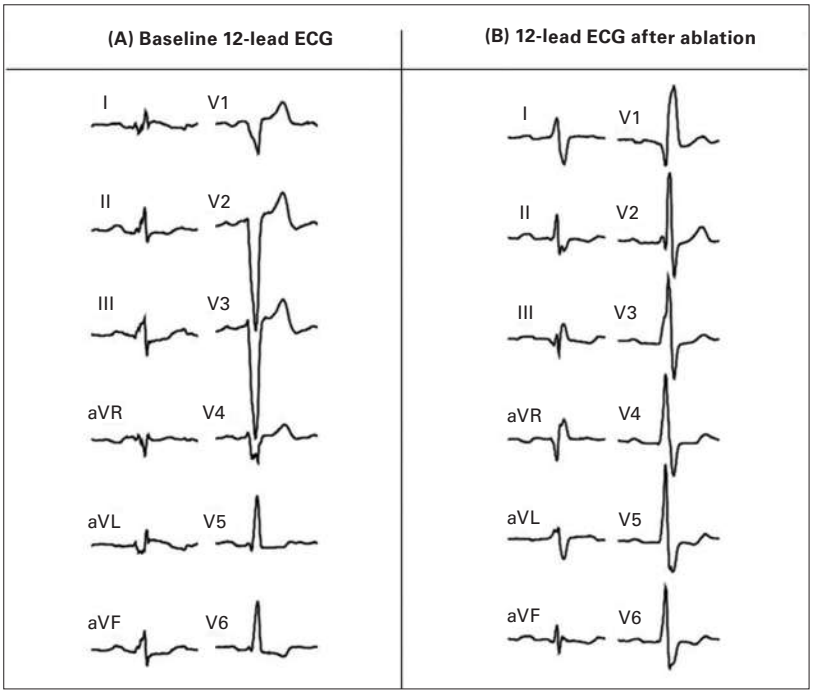

Figure 2: (A) Baseline 12-lead ECG with a left bundle branch block. **(B)** 12-lead ECG after ablation with a right bundle branch block.

An electrophysiological (EP) study was performed. At the time of EP study, the patient was in sinus rhythm (conversion from atrial fibrillation resulting from the most recent ICD shock) with an LBBB configuration (fig. 2A). QRS duration was 138 ms and the HV interval was prolonged to 74 ms. With programmed stimulation from the RV apex, a LBBB-VT with a cycle length of 290 ms could be induced. Every ventricular depolarisation was preceded by a His bundle deflection with an HV interval of 80 ms during tachycardia. Entrainment from the RV apex resulted in a postpacing interval (PPI) – tachycardia cycle length (TCL) of 20 ms. Accordingly, a diagnosis of BBR-VT could be made. Following ablation of the right bundle branch, the surface ECG morphology changed from an LBBB to a right bundle-branch block (RBBB) morphology (fig. 2B) and the tachycardia was no longer inducible. Following the ablation

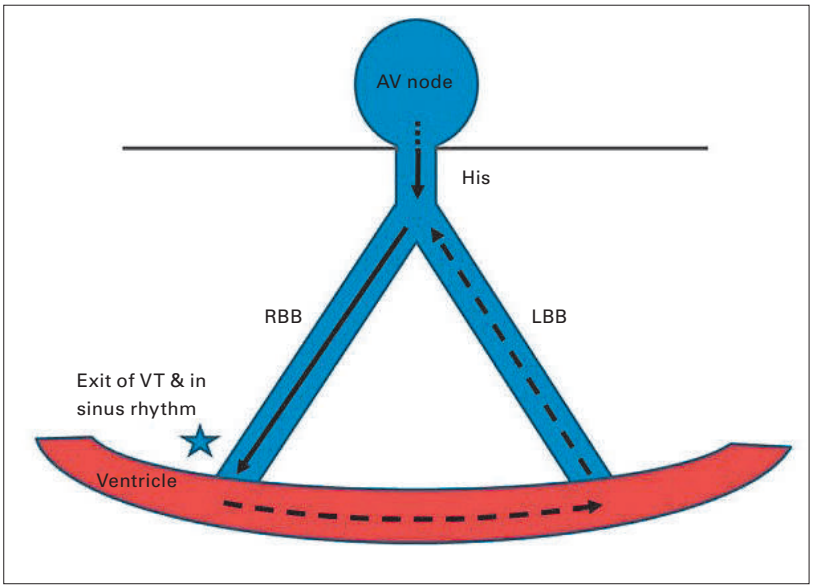

Figure 3: Mechanism of bundle branch reentry ventricular tachycardia (BBR-VT). AV = atrioventricular; LBB = left bundle branch; RBB = right bundle branch; VT = ventricular tachycardia

procedure, the patient has not had any more monomorphic VT in more than a year. Subsequent routine interrogation of his VVI-ICD indicated less than 1% V pacing and he continued in New York Heart Association class II, so that no upgrade to a CRT-ICD system has been performed yet.

BBR-VT is a rare form of VT which most frequently occurs in patients with advanced structural heart disease, in particular in patients with nonischaemic dilated cardiomyopathy, and with preexisting conduction system disease, most typically LBBB [2]. In the most common form of BBR-VT, the right bundle branch serves as the antegrade limb and the left bundle branch as the retrograde limb of the tachycardia circuit (fig. 3). Of note, the LBBB at baseline results from a conduction delay rather than a complete block in the left bundle branch, given that retrograde conduction over the left bundle is a critical part of the circuit. Another prerequisite for sustained BBR-VT is that the conduction times over each bundle are longer than the refractory period of the other bundle. The exit of ventricular activation occurs at the terminal portion of the right bundle branch system, therefore mimicking the QRS and EGM morphology during normal rhythm with LBBB. Antiarrhythmic treatment is often not successful and might even increase the probability of BBR-VT by further slowing conduction velocity. Rather, catheter ablation is the curative treatment of choice [3, 4]. Ablation usually targets the right bundle branch, because it is technically easier due to its superficial location. It often results in a change from LBBB to RBBB as in our patient, and often requires pacing afterwards due to a markedly prolonged HV interval or complete AV block. Even if ablation is successful, ICD implantation is warranted in most patients because of their underlying heart disease [2–4].

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References

1 Chen J, Josephson ME. Atrioventricular nodal tachycardia occurring during atrial fibrillation. J Cardiovasc Electrophysiol. 2000;11(7):812–5.
2 Akhtar M, Gilbert C, Wolf FG, Schmidt DH. Reentry within the His-Purkinje system. Elucidation of reentrant circuit using right bundle branch and His bundle recordings. Circulation. 1978;58(2):295–304.
3 Tchou P, Jazayeri M, Denker S, Dongas J, Caceres J, Akhtar M. Transcatheter electrical ablation of right bundle branch. A method of treating macroreentrant ventricular tachycardia attributed to bundle branch reentry. Circulation. 1988;78(2):246–57.
4 Priori SG, Blomström-Lundqvist C, Mazzanti A, Blom N, Borggrefe M, Camm J, et al. 2015 ESC Guidelines for the management of patients with ventricular arrhythmias and the prevention of sudden cardiac death: The Task Force for the Management of Patients with Ventricular Arrhythmias and the Prevention of Sudden Cardiac Death of the European Society of Cardiology (ESC) Endorsed by: Association for European Paediatric and Congenital Cardiology (AEPC). Eur Heart J. 2015 [Epub ahead of print].