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Repeated misclassifications of tachycardia by an implantable cardiac defibrillator

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ABSTRACT

This case describes repeated misclassifications of SVT due to AV node reentry as VT by an ICD. This case illustrates the limitations of SVT-VT discrimination algorithm. Careful analysis of the stored tracings is of critical importance to reach the correct diagnosis.

1. Introduction

A variety of SVTs are commonly seen in patients with an ICD. Many algorithms have been developed to better discriminate SVT from VT with variable success rates [1–3]. We describe a case with SVT due to AV node reentry in which the SVT-VT discrimination algorism showed 3 different types of misclassifications. Careful analysis of the stored tracings is crucial in the correct diagnosis of the tachycardia.

2. Case report

The patient was a 54-year-old male with a history of ischemic cardiomyopathy who had congestive heart failure, left bundle branch block (QRS duration = 152 m s), and reduced left ventricular ejection fraction of 25%. The patient received a St. Jude Medical biventricular ICD (Promote RF 3207–36).

The device was programmed to the DDD mode with a lower rate of 60 and an upper rate of 130 beats/minute. The rate cut-off for VT was set at 176 beats/minute and that for ventricular fibrillation at 200 beats/minute. The atrial rate cut-off for mode switch for atrial tachyarrhythmia was programmed at 180 beats/minute.

During follow-up, the patient developed numerous supraventricular tachycardia episodes due to AV node reentry, which were repeatedly misclassified as ventricular tachycardia or sinus tachycardia. The patient later underwent electrophysiology study and modification of the slow pathway of the AV node was performed successfully.

Two representative AV node reentry tachycardia episodes are shown here (Figs. 1 and 2). The numbers above the tick marks indicated a morphology score, which showed a good match (Fig. 1A) or a poor match (Fig. 2B). Each episode was initiated by premature atrial beats with an AV interval of 280 m s (not shown here). The first episode showed tachycardia CLs of 290–320 m s (Fig. 2A). The VA interval was 40 m s and the AV interval thus was calculated as 250–280 m s. The A fell into PVAB so that the A was totally blanked. Of note, there were 2 sensed A (AS). At this point, the device misclassified the SVT as VT based on the number of the ventricular electrogram (V) greater than that of the A. This led to antitachycardia ventricular pacing with a constant CL of 270 m s. The atrial tachycardia CL was not affected during ventricular pacing; thus, the tachycardia was not entrained. Upon termination of pacing, the tachycardia resulted in 2:1 AV conduction (Fig. 1B). When every other A fell into the PVAB, the device then misinterpreted it as sinus rhythm with CLs of 612–645 m s, leading to initiation of biventricular pacing (Fig. 1C). The sensed AV delay was set at 100 m s. The tachycardia CL was not affected during pacing. As

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Abbreviations

A	atrial electrogram
AV	atrio-ventricular
CL	cycle length
ICD	implantable cardioverter defibrillator
PVAB	postventricular atrial blanking
SVT	supraventricular tachycardia
V	ventricular electrogram
VA	ventriculo-atrial
VT	ventricular tachycardia

the tachycardia continued, the A fell outside the PVAB resulting in detection of A after which mode switching ensued (Fig. 1D). Fig. 2A showed spontaneous tachycardia termination. The morphology was identical to that during sinus rhythm and no A was seen. The device correctly interpreted this as SVT based on the morphology criteria. The tachycardia demonstrated progressive slowing in tachycardia CL with the fixed VA interval and finally terminated spontaneously with the A.

Fig. 2B showed another tachycardia episode. This tachycardia again was initiated by a prolonged AV interval of 280 m s. Since every A fell within the PAVB, none could be detected by the ICD. The morphology criteria did not match that of the baseline, so it was misclassified as VT, resulting in initiation of antitachycardia pacing. A baseline ECG showed sinus rhythm with a left bundle branch block pattern. Of note, local ventricular electrograms in Fig. 2A and B were similar but the morphology scores were quite different. The poor morphology match could be caused by a tachycardia-induced conduction delay in the myocardium. Other possibility is that the left bundle branch block pattern was due to a conduction delay rather than block in the left bundle. The tachycardia then led to a greater degree of the conduction delay in the right than the left bundle; this resulted in a different QRS morphology. The AA interval was 340 m s (Fig. 2C), which stayed the same during rapid straight ventricular pacing with a CL of 280 m s, and abruptly was terminated.

3. Discussion

Current ICDs have sophisticated algorithms to differentiate SVT from VT [1–3]. These include abrupt onset, morphology criteria, comparision of atrial and ventricular rates, AV dissociation, PR pattern, and others [1–3]. Nonetheless, a substantial number of tachycardia episodes are still misclassified. This misclassification then can result in inappropriate initiation or suspension of tachycardia therapy [4,5]. Most of inappropriate shocks are due to a variety of SVTs [5]. Stored electrograms often are required to verify or reject the true tachycardia mechanism. Our case was interesting in that the SVT-VT discrimination algorithm led to 3 types of misclassification.

The first tachycardia was initiated with AV interval prolongation,

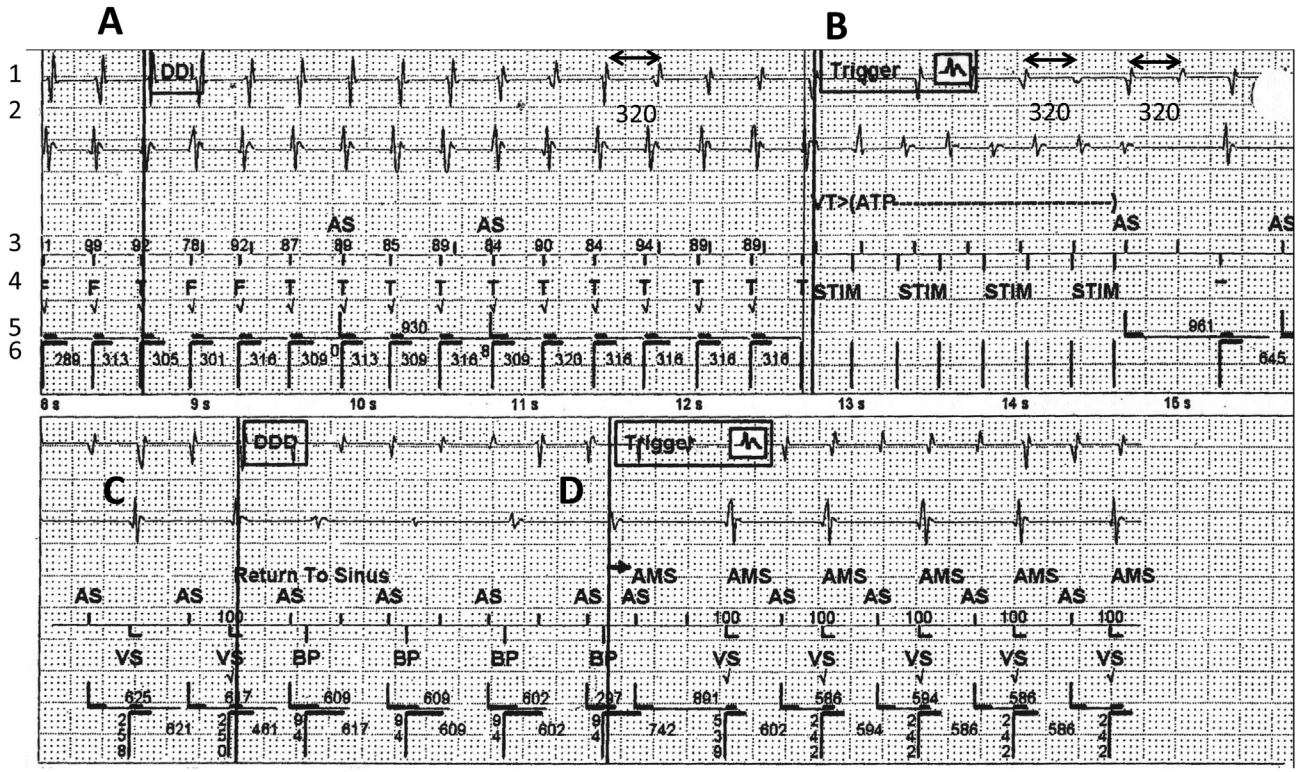

Fig. 1. Misinterpretation of tachycardia by the ICD. Starting from the top, 1 = atrial electrogram, 2 = ventricular electrogram, 3 = atrial marker channel (number indicates a morphology score), 4 = ventricular marker channel (T indicates tachycardia and F indicates fibrillation), 5 = atrial marker channel (refractory period and AA interval), 6 = ventricular marker channel (AV interval, absolute refractory period, and VV interval). Paper speed was 25 mm/s. A: Tachycardia showed cycle lengths (CL) of 290–320 m s. The ventriculo-atrial (VA) interval was 40 m s. B: The atrial electrogram (A) fell into the postventricuar atrial blanking (PVAB). There were 2 atrial electrograms detected (AS) that were interpreted as VT based on the number of the ventricular electrogram (V) greater than A. Anti-tachycardia ventricular pacing with a constant CL of 270 m s was initiated but the AA interval was not affected. Upon termination of pacing, the tachycardia resulted in 2:1 AV conduction. C: Every other A fell into the PVAB and it was interpreted as sinus rhythm at 98 bpm, leading to initiation of biventricular pacing. The sensed AV delay was set at 100 m s. The tachycardia CL was not affected during pacing. D: Every A was detected and the mode switch ensued.

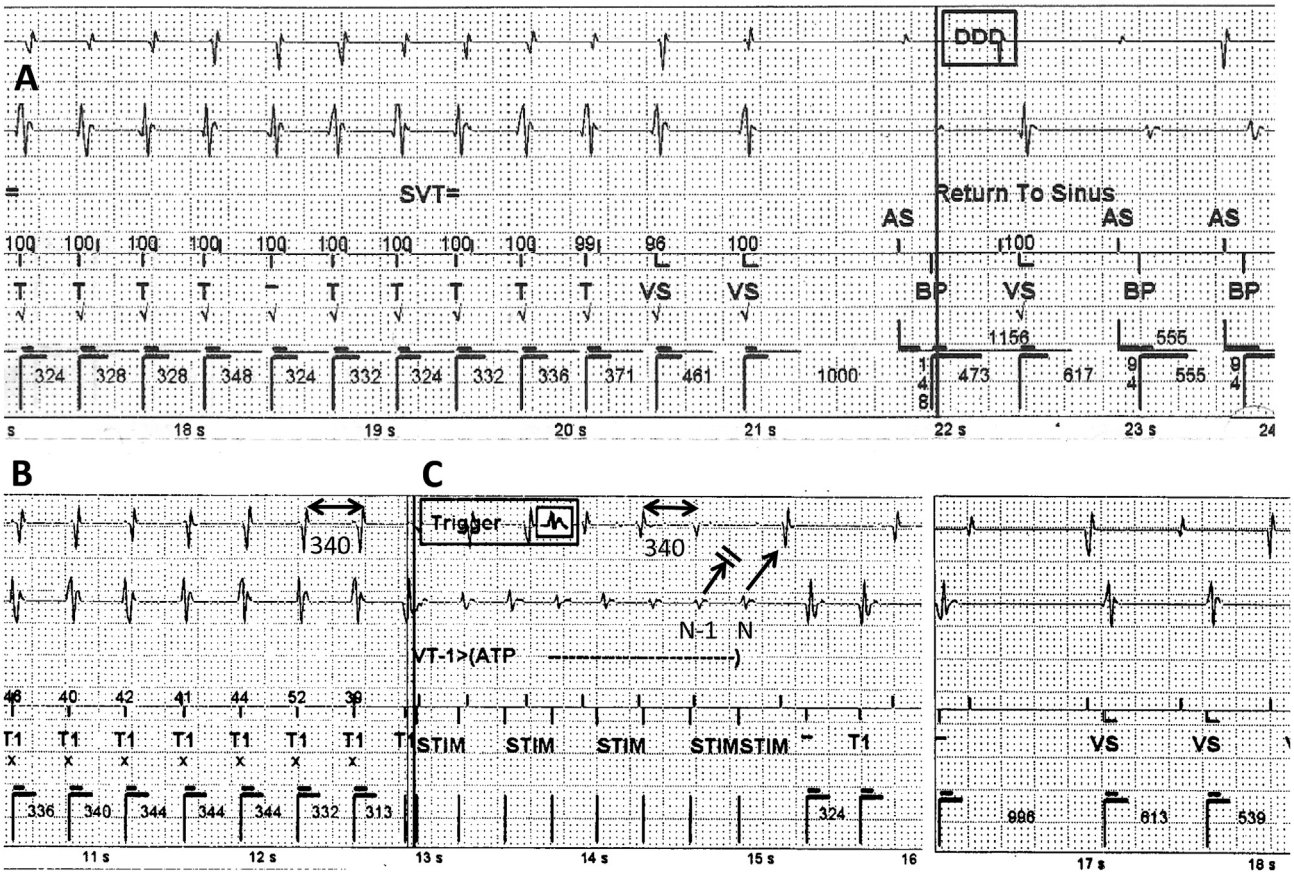

Fig. 2. A and B had the same format as in Fig. 1. Paper speed was 25 mm/s. A. Spontaneous termination of tachycardia. There was short VA interval, fixed VA interval despite tachycardia CL fluctuation (VA linking), and termination with the atrial electrogram. This is consistent with AV node reentry. The perfect morphology match correctly interpreted it as SVT. B. Another tachycardia due to AV node reentry. Note that the morphology score showed a poor match, suggestive of a different QRS morphology during tachycardia. This was misclassified as VT and antitachycardia pacing was initiated. C. The AA interval was 340 m s, which remained the same during ventricular pacing with a CL of 280 m s, and abruptly terminated with the second from the last pacing (N-1) without atrial capture. The last ventricular pacing (N) showed intact VA conduction. Rapid ventricular pacing induced a 3-beat ventricular tachycardia before sinus tachycardia was restored.

which was suggestive of unidirectional block in the fast pathway and exclusive conduction via the slow pathway in the AV node in tachycardia initiation. There was short VA interval, fixed VA interval despite tachycardia CL fluctuation (VA linking), and termination with the atrial electrogram (Fig. 2A). Furthermore, 2:1 AV block developed during tachycardia (Fig. 1C and D). These findings are consistent with AV nodal reentrant tachycardia, likely the slow-fast type. The short VA interval and 2:1 AV block exclude AV reentrant tachycardia, using an accessory pathway. The VA linking and termination of tachycardia with the atrial electrogram are incompatible with atrial tachycardia. Thus, it was consistent with AV node reentry and the AV block occurred below the turnaround of the tachycardia circuit [6].

The second tachycardia was initiated by a prolonged AV interval, short VA interval, and was terminated by VA block during rapid ventricular pacing without affecting the AA interval (Fig. 2C).

Fig. 3 illustrates the second tachycardia mechanism demonstrated in Fig. 2B and C. Rapid ventricular pacing (N-3 and N-2) did not affect the tachycardia until the second from the last pacing (N-1) abruptly terminated it with VA block. This suggests that the

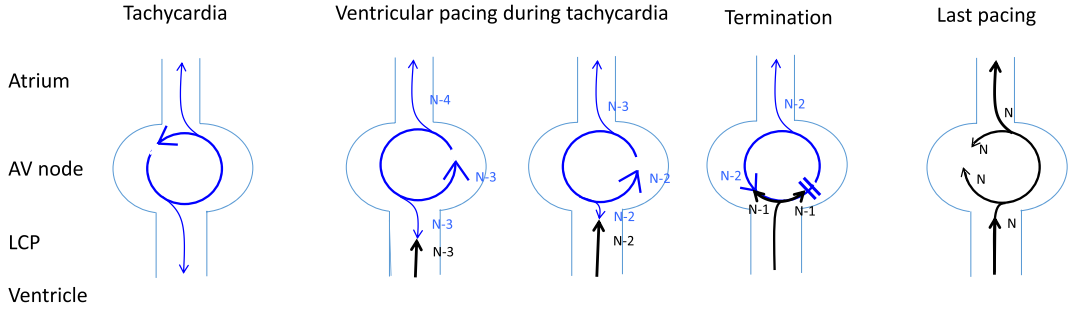

Fig. 3. Proposed termination mechanism of tachycardia by ventricular pacing shown in Fig. 2. Rapid ventricular pacing (N-3 and N-2) did not affect the tachycardia until the second from the last pacing (N-1) abruptly terminated it with VA block. The last pacing (N) resulted in intact VA conduction via the presumed fast pathway. This suggests that the ventricular stimulus (N-1) entered the tachycardia circuit and terminated it within the AV node. Thus, AV node is part of the tachycardia circuit.

ventricular stimulus (N-1) entered the tachycardia circuit and terminated it within the AV node. Thus, AV node is crucial in the tachycardia circuit, which argues against atrial tachycardia.

This case illustrated 3 types of misclassifications using the sophisticated SVT-VT discrimination algorithm. Careful analysis of stored ICD tracings often is required to better understand the true tachycardia mechanism.

Declaration of competing interest

None.

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