An unusual ICD shock: What is the mechanism?

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Introduction

Tachyarrhythmia detection and therapy in implantable cardioverter-defibrillators (ICDs) are governed by specific algorithms for ventricular sensing, initial detection, atrial arrhythmia discrimination, redetection, and reconfirmation, and these are manufacturer-specific. We report a case of an unusual ICD shock in a Boston Scientific dual-chamber ICD and discuss the mechanism.

Case report

A 48-year-old man with nonischemic dilated cardiomyopathy, left ventricular ejection fraction ≤35% status post dual-chamber ICD (Boston Scientific Energen, model E142) since September 2012, history of ventricular tachycardia with antitachycardia pacing (ATP) therapy, paroxysmal atrial fibrillation, and atrial tachycardia on beta-blocker therapy was seen in clinic following an ICD shock. The patient complained of palpitations but denied syncope or presyncope. Physical examination was without any abnormal cardiac findings and a 12-lead electrocardiogram showed atrial-paced rhythm at 60 beats per minute (bpm), normal intervals, and nonspecific inferolateral ST-T abnormalities. Device interrogation showed normally functioning atrial and ventricular leads with the following programmed parameters: Brady programming: DDD 60-115 with paced and sensed atrioventricular (AV) delay of 300 msec; Tachy programming: Three zones—VF zone (200 bpm [300 msec]) with ATP during charging, VT zone (170 bpm [353 msec] with atrial arrhythmia discrimination [Rhythm ID]), and a VT-1 monitor-only zone with detection rate of 140 bpm [428 msec].

ICD tracings showing the arrhythmia episode that resulted in the 31 joule shock are shown in Figures 1–3 as a continuous strip. Why did this patient get shocked?

Review of Figure 1 shows a long RP tachycardia with variable cycle length (range 405–480 msec) and 1:1 AV relationship. During cycle length variability ("wobble"), A-A appears to predict V-V, suggesting a supraventricular mechanism, with a focal atrial tachycardia (AT) being the likely cause. Initial detection of this tachycardia was met in the monitor-only zone (marker channel showing VT-1). Boston Scientific ICDs require 3 consecutive "fast" beats with cycle lengths within a specified detection window (such as a VF or VT-1 zone) to initiate tachyarrhythmia detection. The detection window is satisfied and an episode is declared when 8 of 10 fast beats are counted and the device starts a duration timer, which is programmable. However, if the 8 of 10 fast intervals threshold is not met, the detection window remains open and detection can continue as long as 6 of 10 beats continue to be classified as fast. Figure 1A shows an isolated end-of-episode PVP (postventricular atrial refractory period after premature ventricular contractions) marker at VS 440 msec (black arrow). This indicates that the tachycardia no longer meets the 6 of 10 beats criteria required for continued detection in the VT-1 monitor zone and that the episode has ended. Therefore, a nonprogrammable 10-second end-of-episode timer is started.

Figure 1B, however, shows burst ATP therapy. How did this happen?

During the above-mentioned nonprogrammable 10-second timer, the initial AT appears to transition to a faster, short RP tachycardia, now with a cycle length of 275–308 msec and still maintaining 1:1 AV relationship, and gets redetected in the VT-1 zone (8/10 beats). This detection is met at the interval marked as VF 293 msec (red arrow). Simultaneously, detection is ongoing in the VT zone (8/10 beats) as well as in the VF zone (8/10 beats). VT zone detection is met at the interval marked VF 278 msec. At the next beat (interval marked VF 300 msec), the VF detection window is met (red asterisk), and therefore duration periods are started for all 3 zones. The duration period is a timer that denotes the amount of time in each zone that the tachyarrhythmia has to be sustained before therapy is delivered. If

KEYWORDS Inappropriate shock; Monitor zone; Atrial tachycardia

ABBREVIATIONS **AT** = atrial tachycardia; **ATP** = antitachycardia pacing; **AV** = atrioventricular; **ICD** = implantable cardioverter-defibrillator; **LIZ** = last-in-zone; **QC** = quick convert; **SVT** = supraventricular tachycardia; **VP** = ventricular pace; **VS** = ventricular sense

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KEY TEACHING POINTS

- This case represents a scenario where a programmed monitor zone in a Boston Scientific dual-chamber implantable cardioverter-defibrillator (ICD) resulted in an inappropriate shock for a supraventricular tachycardia.
- Conservative reconfirmation algorithms can, in certain scenarios, result in inappropriate therapy, especially in the presence of monitor zones.
- It is important to be aware of the detection, duration, and reconfirmation criteria of the specific ICD to optimize tachy zone programming, especially initial detection windows, duration timers, and monitor zones.

more than 1 duration timer is running simultaneously, the highest zone is in control, and no therapy decision will be made until the highest-zone duration timer expires. Since the VF zone is in control, the duration of detection in this zone is 1 second and requires 6 of 10 VF beats plus the last-in-zone (LIZ) beat to be in the VF zone to declare end of duration and therapy delivery. Although this is still a 1:1 tachycardia, Rhythm ID is not active in the VF zone. Still on Figure 1, at the interval marked VT 308 msec (notched black arrow), VF duration is met (V-Dur), but the LIZ beat is in the VT zone by cycle length. Since LIZ is not met, the duration is extended by 1 more beat. So at VF 293 msec (black asterisk), there are 6 of 10 fast beats in the VF zone (actually 8/10 beats because there are 2 VT beats). The quick convert (QC) (ATP during charging) cycle length cutoff is >240 msec. Averaging the cycle lengths of the 4 beats leading up to the V-Detect marker (indicating that VF zone detection criteria have been met) yields a mean cycle length of 298.5 msec/201 bpm (293 + 308 + 285 + 308 msec/4). So QC is initiated at 88% of tachycardia cycle length (260 msec) for 8 pulses.

Apparent resolution of the rapid 1:1 tachycardia is noted following QC (Figure 2A). However, the device continues to

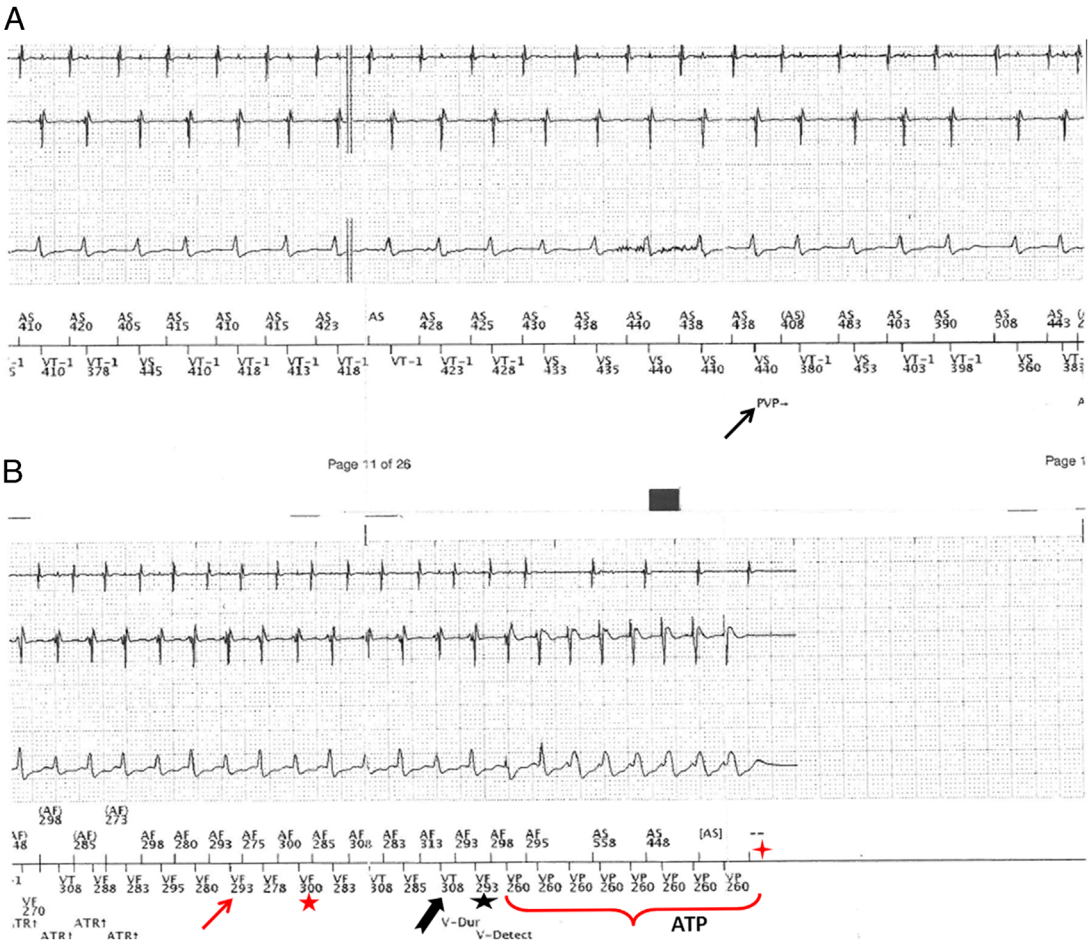

Figure 1 **A:** Upper panel shows a long RP supraventricular tachycardia (SVT) with 1:1 atrioventricular (AV) relationship (likely atrial tachycardia) with cycle length ranging from 405 to 480 msec that was detected in the VT-1 monitor zone (rate cutoff: 140 bpm). Black arrow shows PVP (postventricular atrial refractory period after premature ventricular contractions) marker indicating end of episode, as 6 of 10 beats required for continued detection is not satisfied. **B:** The initial SVT now transitions into a faster, short RP SVT, still with 1:1 AV relationship and cycle length from 275 to 308 msec. Red arrow shows detection of this SVT in the VT-1 zone and red asterisk indicates detection in the VF zone. Notched black arrow denotes expiration of VF duration timer. Black asterisk indicates that VF zone duration is met and device then delivers ATP at 260 msec cycle length. The red 4-pointed star following ATP denotes that this beat is ignored for reconfirmation purposes.

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