Pacemaker-induced tachycardia in a DDI-programmed ICD: What is the mechanism?

Haseeb Jafri, MD, Alan Cheng, MD, FHRS

From the Section of Cardiac Electrophysiology, Division of Cardiology, Johns Hopkins University School of Medicine, Baltimore, Maryland.

Introduction
Dual chamber pacing systems utilize different timing cycles to provide pacing support and coordination of atrioventricular synchrony. At times, this can result in unexpected pacing behavior. This case illustrates one such example.

Case report
A 64-year-old man with a history of nonischemic cardiomyopathy received a St. Jude Medical (Sylmar, CA) dual-chamber implantable cardioverter-defibrillator (ICD) in 2011. He had sick sinus syndrome with intact atrioventricular (AV) conduction. He was recently admitted to the hospital for treatment of pneumonia. His ICD was programmed to DDI pacing at 90 beats per minute (bpm) with a paced AV interval of 350 milliseconds.

While on telemetry, the patient was noted to have non-sustained episodes of pacing-associated tachycardia at a rate of approximately 150 bpm. His ICD was interrogated and found to be functioning normally. Because a ventricular tachycardia monitor zone was programmed to 130 bpm, data found to be functioning normally. Because a ventricular tachycardia monitor zone was programmed to 130 bpm, data from the tachycardia episode were stored. Review of the data revealed atrial pacing at a rate of approximately 150 bpm. What could be causing the device to pace at a rate faster than what was programmed?

Discussion
Dual-chamber pacing requires the coordination of timing cycles from both the atrium and the ventricle. Hence, a given pacing mode (eg, DDD, DDI, managed ventricular pacing) can operate predominantly based on atrial- or ventricular-based timing intervals. Whereas managed ventricular pacing and DDD pacing modes rely on modified atrial-based algorithms, DDI pacing mode uses ventricular-based timing cycles. Hence, the cycle length between 2 atrial paced events is dictated not on the A-A interval but on the V-A interval. This feature is illustrated in Figure 1. The device was programmed to DDI 90 (approximately 662 milliseconds) with a programmed paced AV delay of 350 milliseconds.

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Conflicts of interest: No funding was provided for this case report. A.C. has received honorarium from Boston Scientific, Medtronic, and St. Jude Medical. Address reprint requests and correspondence: Dr. Alan Cheng, 600 North Wolfe Street, Halsted 565, Baltimore, MD 21287. E-mail address: alcheng@jhmi.edu.

KEYWORDS ICD; Pacing; Timing cycles; DDI; Repetitive reentrant atrioventricular synchrony

ABBREVIATIONS AP = Atrial paced; DDD = Dual-chamber pacing, dual-chamber sensing, dual response; DDI = Dual-chamber pacing, dual-chamber sensing, inhibited response; ICD = Implantable cardioverter-defibrillator; PAC = Premature atrial complex; VS = Ventricular-sensed (Heart Rhythm Case Reports 2015;1:198–200)
Figure 1  Atrial pacing at baseline. The device was programmed to DDI 90 (662 milliseconds) with a programmed paced AV interval of 350 milliseconds. This resulted in a VA interval of $662 - 350 = 312$ milliseconds. Because DDI pacing is dependent on ventricular-based timing cycles, the next atrial paced (AP) event is not triggered 662 milliseconds from the preceding AP event. Rather, it occurs 312 milliseconds from the preceding ventricular-sensed event. Hence, the AP-AP interval is actually $297 + 312 = 609$ milliseconds. See text for details.

Figure 2  Recorded episode of tachycardia from implantable cardioverter-defibrillator device: repetitive reentrant atrioventricular synchrony. A: Three premature atrial complexes (PAC, asterisks) are seen, each conducting through the AV node to the ventricle (green arrows). The first PAC is sensed (AS), the second fell in the refractory period (noted with marker), and the third fell in the blanking period (no label or marker). The timing of the VS events is fortuitous such that they occur just outside the postatrial ventricular blanking period of the preceding atrial pacing (AP) event. Given the ventricular-based timing cycle, the next AP then occurs 312 milliseconds (calculated VA interval based on programmed lower pacing rate and paced AV interval) afterward. The tachycardia persists and eventually terminates because of decremental block in the AV node. See text for details. B: An illustration of the same episode of tachycardia captured on bedside telemetry. Leads II and V1 are shown. Atrial pacing with intrinsic ventricular conduction is observed. Loss of atrial pacing is seen to occur with the fourth QRS complex (red arrow), with subsequent pacing-associated tachycardia. The QRS morphology during tachycardia is similar to that of the initial portion of the rhythm strip, arguing against a ventricular tachycardia. At the termination of the tachycardia, the pacing spike to the QRS interval appears to begin lengthening (blue arrow) with abrupt termination of tachycardia and resumption of atrial pacing at a slower rate.
node such that the second-to-last AP event (red ↓) blocks in the AV node and allows the device to return to pacing at slower rates. This phenomenon was also nicely illustrated in the telemetry recordings obtained at the bedside (Figure 2B).

**Conclusions**

DDI is a ventricular-based pacing mode and the cycle length between 2 atrially paced events is dictated by the V-A interval. With greater emphasis on minimizing right ventricular pacing, the programmed paced AV delay is often lengthened, thus resulting in a shorter V-A interval. When intrinsic conduction times through the AV node are faster than the programmed paced AV delay, the lower rate of pacing (ie, cycle length between 2 AP events) is necessarily faster than what is programmed. In this example, the VS events resulting from the 3 fortuitously timed PACs managed to occur just outside the PAVB of the preceding AP event, thus resulting in a form of “pacemaker-mediated tachycardia”. Unlike traditional pacemaker-mediated tachycardia (also known as “repetitive reentrant ventriculoatrial synchrony”), where tachycardia is mediated by ventricular pacing in response to atrial sensed events, the tachycardia in this example is mediated by atrial pacing in response to VS events. Hence, we have termed this phenomenon “repetitive reentrant atrioventricular synchrony”. In an effort to reduce the likelihood of this event, we reprogrammed the device to an atrially based pacing mode (eg, DDD). Other possible solutions to reduce the likelihood of repetitive reentrant atrioventricular synchrony include lengthening the PAVB interval (not available in this device), reducing the lower pacing rate and shortening the programmed paced AV interval.

**References**

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