Broad Complex Tachycardia in a Patient with a Dual-chamber Pacemaker. What is the Mechanism?

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KEYWORDS. broad complex tachycardia, pacemaker.

Introduction

A 72-year-old male with prior history of coronary artery disease and coronary artery bypass graft was implanted with a dual-chamber pacemaker (St. Jude Medical Assurity DR 2260, Sylmar, Minneapolis, MN) due to high degree atrioventricular block. One year after implant, the patient presented to the emergency room (ER) complaining of palpitations and presyncope. In the ER, the patient was at 115 bpm and the surface 12-lead electrocardiogram showed a wide-complex tachycardia with left bundle branch block-like morphology (Figure 1). Pacemaker-mediated tachycardia (PMT) versus an atrial tachycardia with ventricular tracking was considered in the initial differential diagnosis. Ventricular tachycardia was less likely since the QRS complex morphology was identical to the paced morphology, and a pacing artifact was visible before every ventricular complex. The tachycardia terminated spontaneously during patient assessment, and interrogation of the device was requested. Several events like the one shown in Figure 2 were downloaded. Programming of the pacemaker is depicted in Table 1.

What is the mechanism of the tachycardia and its termination?

Discussion

Analysis of the intracardiac electrograms reveals a fast atrial rhythm with a stable cycle length (CL) of 260 ms, likely atrial tachycardia or flutter. As can be seen, every other P wave of the tachycardia falls in the postventricular atrial blanking period (PVAB), and therefore is ignored by the device and not marked on the annotation channel. This type of functional undersensing results in failure to mode switch and 2:1 tracking of the atrial activity, also called “2:1 lock-in phenomenon.”

Shortly after initiation of the tachycardia, the sensor indicator rate (SIR) is triggered, likely induced by patient activity. This initiated atrial pacing at the SIR, which is slightly faster than the atrial rate sensed by the pacemaker (115 bpm, corresponding to a CL of 520 ms or twice the real atrial CL), followed by ventricular pacing after the programmed paced AV delay of 250 ms. As the sensor rate accelerated, this led to a progressive...
shortening of CL from 520 ms to 457 in the subsequent cycles. This moved the atrial depolarization outside the PVAB and then out of the post-ventricular atrial refractory period (PVARP), allowing sensing of the tachycardia (atrial refractory (AR) and atrial sense (AS)) and triggering the automatic mode switch (AMS) algorithm with change to DDIR mode.

The “2:1 lock-in phenomenon” has been previously described and some programming alternatives to overcome this issue have been reported:1

a) shortening of the PVAB to allow sensing of the F-waves;  
b) shortening of the AV delay after atrial sensed events to increase the likelihood of every second flutter wave to be sensed outside the PVAB;  
c) rate adaptive AV delay to allow programming longer adaptive PVARP; and  
d) decreasing the upper tracking rate (UTR) below half the flutter rate to produce Wenckebach behavior once half the flutter rate is reached. In this case, once the maximum UTR (110 bpm, 545 ms) falls below the filtered atrial rate interval (FARI) CL (FARI that is regularly updated by the device) of “521.7 mms/115 bpm” for nine subsequent cycles then AMS algorithm will be triggered. However, lowered UTR to 110 would limit the patient activities that are expected for his age.

In summary, this case represents a case of atrial tachycardia/flutter with functional undersensing of every other F-wave and mode switching failure, resulting in 2:1 tracking of the atrial rhythm. The phenomenon, fortunately, is terminated by triggering of the SIR, which initiates atrial pacing and moves the atrial sensed activity out of the PVAB, allowing appropriate mode switching.

**Table 1: Programmed parameters**

<table>
<thead>
<tr>
<th>Mode</th>
<th>DDDR</th>
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<tbody>
<tr>
<td>Rate “bpm” Upper/Lower</td>
<td>130/60</td>
</tr>
<tr>
<td>Mode switch</td>
<td>DDIR</td>
</tr>
<tr>
<td>Mode switch/detection rate</td>
<td>On 171 bpm</td>
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<tr>
<td>PVARP/PVAB</td>
<td>175–125 ms/150 ms</td>
</tr>
<tr>
<td>Max SIR</td>
<td>416 ms/144.2 bpm</td>
</tr>
<tr>
<td>sAVI/pAVI</td>
<td>200 ms/250 ms</td>
</tr>
</tbody>
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PVAB: post-ventricular atrial blanking period; PVARP: post-ventricular atrial refractory period; SIR: sensor indicator rate.

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**Figure 1:** Surface 12-lead electrocardiogram depicting a wide-complex tachycardia with left bundle branch block-like morphology.
Figure 2: Intracardiac recording and marker channels from the device. See text for details.

References
