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Paradoxical Undersensing During Atrial Flutter: What Is the Mechanism?

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Pacemaker Undersensing During Atrial Flutter. A patient with congenital complete heart block underwent implantation of a dual-chamber pacemaker. He presented to the emergency room with fatigue and was found to be in atrial flutter. Device interrogation revealed undersensing of 5 mV flutter waves at a programmed sensitivity of 0.5 mV. Due to undersensing, mode switch did not occur. This case illustrates apparently paradoxical undersensing of atrial flutter waves by a dual-chamber pacemaker and can be explained by a phenomenon known as "quiet timer blanking."

atrial flutter, pacemaker undersensing, quiet timer blanking

Case Summary

A 30-year-old male with a history of congenital complete heart block underwent implantation of a Medtronic EnPulse® dual-chamber pacemaker Model E1DR01 (Medtronic Corporation, Minneapolis, MN, USA). After implant, the patient was lost to follow-up.

Two years later, he presented with complaints of fatigue. On presentation, his physical exam and diagnostic testing proved unremarkable. Occasional atrial pacing on telemetry in the emergency department prompted interrogation of the pacemaker. The programmed parameters, lead information and initial interrogation results are shown in Table 1. The rhythm was found to be atrial flutter (cycle length 220 msec) and complete heart block. The measured P wave amplitude was 5.6-8 mV and was confirmed by manual measurement of the printed atrial electrogram. The atrial sensitivity was set at 0.5 mV bipolar (Fig. 1).

At a programmed sensitivity of 0.5 mV, only one of every two or three flutter waves was sensed by the device. Despite the variability in flutter wave amplitude, all were greater than 5 mV and therefore should have been sensed. As evident in Figure 1, the second flutter wave is within the post-ventricular atrial blanking period and is not sensed. The third flutter wave in the cycle falls outside any blanking or refractory period and is not sensed either. Due to undersensing of two of every three flutter waves, mode switch did not occur. At a sensitivity of 0.5 mV, there was atrial undersensing.

The sensitivity was programmed to 0.18 mV and none of the flutter waves were sensed. This resulted in atrial and ventricular sequential pacing at the lower rate limit (Fig. 2).

Atrial sensitivity was then programmed to 1.0 mV and proper atrial sensing was noted resulting in mode switching to a nontracking mode (Fig. 3). P wave amplitudes measured 5.6–8 mV during atrial flutter.

What is the mechanism for this paradoxical undersensing of atrial activity during atrial flutter? Why did increasing the atrial sensitivity (e.g., programmed from 0.5 mV to 0.18 mV) make the undersensing worse and decreasing the atrial sensitivity (e.g., programmed from 0.5 mV to 1.0 mV) make it better?

Discussion

This case illustrates apparently paradoxical undersensing of atrial electrograms during atrial flutter by a dual-chamber pacemaker. As the atrial sensitivity was increased (e.g., programmed from 0.5 mV to 0.18 mV), undersensing became worse. As atrial sensitivity was decreased (e.g., programmed from 0.5 mV to 1.0 mV), paradoxically sensing improved and appropriate mode switching occurred.

This observation can be explained by a phenomenon coined "quiet timer blanking." The quiet timer blanking intervals occur following any paced event or sensed event with a sufficiently large signal on the sense amplifiers in current Medtronic pacemakers.[1] These intervals are intended to let the noise or signals created by these events to diminish in amplitude or completely stop "ringing" through the sense amplifier circuitry before bringing the sense amplifier back on line. The larger the signal, the longer the "ringing" effect. If repetitive signals are inputted into the sense amplifier, these quiet timer intervals can be restarted and extended.

The normal quiet timer interval in the EnPulse® pacemaker ranges from 50–100 msec and is not a programmable feature. With very large amplitude or long duration sensed signals and/or high levels of post-pace polarization, these quiet timer blanking periods can cover the entire atrial sensing window.

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TABLE 1
Programmed Parameters

Mode	**DDDR**		
		Atrial lead (Medtronic 5076)	
Mode switch	On/175 bpm	Amplitude	2.5 V
Blanked flutter search	On	Pulse width	0.34 msec
Lower rate	60 ppm	Sensitivity	0.5 mV
Upper tracking rate	160 ppm	Sensing assurance	On
Upper sensing rate	160 ppm	Polarity	Bipolar
PVARP	Auto	Ventricular lead (Medtronic 4024)	
Minimum PVARP	250 msec	Amplitude	3.5 V
PVAB	180 msec	Pulse width	0.4 mV
Ventricular refractory	230 msec	Sensitivity	2.8 mV
Ventricular blanking (after atrial pacing)	28 msec	Polarity	Bipolar

Whenever the ventricular amplifier is in the quiet timer interval, a quiet timer interval is also automatically enforced in the atrial sense amplifier to avoid far-field sensing. This cross-chamber atrial quiet timer interval always extends about 37 msec longer than the corresponding ventricular quiet timer interval.

In the present case, a failure to sense flutter waves at a sensitivity of 0.50 mV occurred due to the presence of large amplitude flutter waves resulting in the onset of frequent quiet timer blanking intervals. This resulted in failure of the pacemaker to undersense flutter waves. When the programmed sensitivity was increased, more "ringing" occurred in the sense amplifier and repetitive cycling of the quiet timer blanking intervals occurred, resulting in failure to sense any of the flutter waves. Paradoxically, when the programmed sensitivity was decreased, less "ringing" occurred in the sense amplifier and the repetitive cycling of quiet timer blanking intervals terminated. At this sensitivity (e.g., 1.0 mV), the pacemaker properly mode switched.

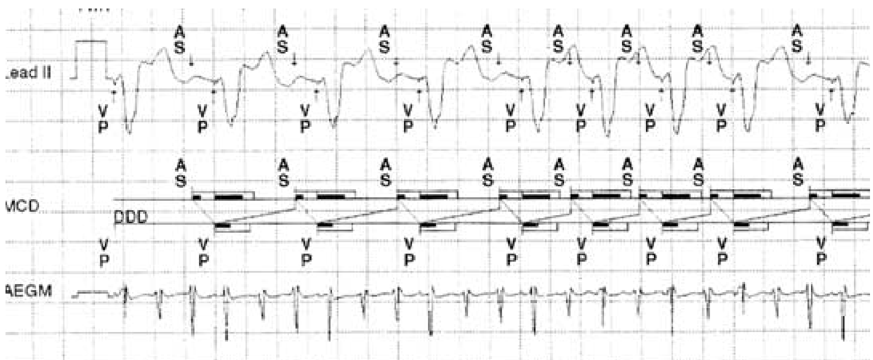

Figure 1. *Atrial sensitivity 0.50 mV. Surface lead II, marker channel diagrams (MCD), and intracardiac atrial electrograms (AEGM) with atrial sensitivity at 0.5 mV. The device is set to DDD and has not mode switched due to atrial undersensing. Black bars in MCD indicate blanking periods and open bars indicate refractory periods. AS = atrial sensed event; VP = ventricular paced event.*

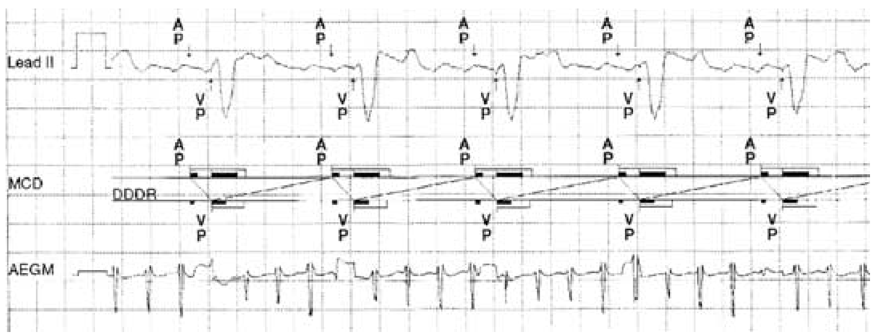

Figure 2. *Atrial sensitivity 0.18 mV. Surface lead II, marker channel diagrams (MCD), and intracardiac atrial electrograms (AEGMS) with atrial sensitivity at 0.18 mV. The device is set to DDDR and is pacing in the atrium (AP) and the ventricle (VP). The device has not mode switched due to atrial undersensing. Black bars in MCD indicate blanking periods; open bars indicate refractory periods. AP = atrial paced event; VP = ventricular paced event.*

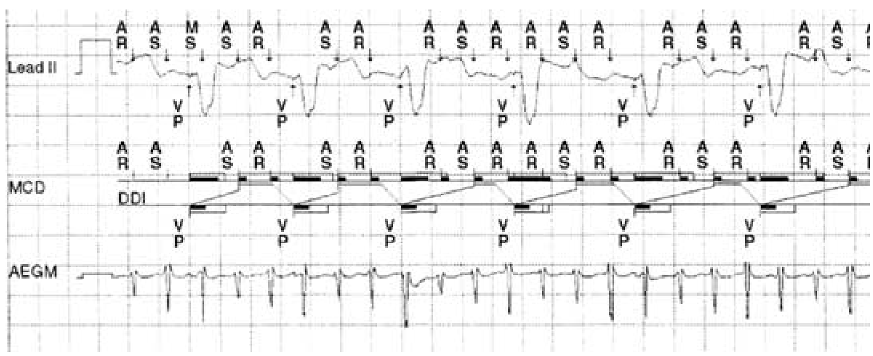

Figure 3. *Atrial sensitivity 1.0 mV. Surface lead II, marker channel diagrams (MCD), and intracardiac atrial electrograms (AEGM) with atrial sensitivity at 1.0 mV. The device has mode switched (denoted by MS) to DDI. Black bars in MCD indicate blanking periods; open bars indicate refractory periods. AR = atrial refractory sensed event; AS = atrial sensed event; VP = ventricular paced event.*

Conclusions

In summary, quiet timer blanking can be clinically important with a relatively uncommon set of circumstances. The combination of rapid atrial rates and very large sensed atrial electrogram relative to the programmed sensitivity can result in "undersensing" and failure to appropriately mode switch. Less sensitive settings or longer ventricular blanking periods are needed to overcome this effect.

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Reference

1. Beeman AL, Deutsch G, Rea RF: Paradoxical undersensing due to quiet timer blanking. Heart Rhythm 2004;3:345-347.