T-wave oversensing during left ventricular pacing causing inappropriate defibrillation

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Introduction
Cardiac resynchronization therapy (CRT) with left ventricular (LV)-only pacing has emerged as an alternative to biventricular (Bi-V) pacing used to synchronize ventricular contraction by timing LV pacing with intrinsic right ventricular (RV) conduction. Additionally, RV pacing is minimized, improving device longevity. Despite its benefits, LV pacing may not be the best modality for all patients. We present a case of T-wave oversensing (TWOS) during LV-only pacing using a dynamic, proprietary algorithm resulting in diminished ventricular pacing and inappropriate defibrillation. This resolved with reprogramming to Bi-V pacing, providing a solution to a unique problem.

Case report
A 55-year-old man received a shock from a CRT defibrillator (Medtronic Viva Quad XT, Medtronic Inc, Minneapolis, MN) while carrying loads of groceries. The device was implanted 8 months prior for nonischemic cardiomyopathy with an ejection fraction of 20%, NYHA class III symptoms, and a left bundle branch block with a QRS duration of 166 ms. The device was programmed with the following parameters: DDDR mode, tracking rate 60–130 beats/min (bpm), fixed atrioventricular (AV) delays (paced: 140 ms, sensed: 130 ms), ventricular tachycardia zone: 176–222 bpm, ventricular fibrillation (VF) zone: >222 bpm, adaptive LV pacing on, ventricular sense response on, ventricular safety pacing on, ventricular blanking post–ventricular pacing 200 ms. No TWOS was observed at the time of implant.

Interrogation of the device upon admission revealed ventricular pacing at 77% of the time. Of that, 33% was Bi-V and 67% LV pacing. This was a dramatic change from interrogation shortly after implantation that showed 96% pacing, which was mainly LV pacing at 82% of the time. There was frequent TWOS, predominantly during LV pacing, with inadequate ventricular pacing and inappropriate detection of VF. The device was able to distinguish oversensing and avoid therapy in 217 episodes, failing to do so on 1 occasion, delivering a single shock. Several maneuvers were attempted to correct TWOS, including altering the AV

Figure 1 Stored electrograms during an episode of ventricular fibrillation sensing, resulting in delivery of a 35.6 J countershock. The intrinsic rate is approximately 130 beats/min. The fourth beat is the only paced beat. The upper electrogram (EGM) is the atrial activity and the lower strip is the ventricular activity. AS = atrial sense; AR = atrial sensing falling within the refractory period; Ab = atrial blanking; VS = ventricular sense; BV = biventricular pacing.

KEYWORDS T-wave oversensing; Inappropriate shock; Left ventricular–only pacing; Cardiac resynchronization therapy troubleshooting; Implantable cardioverter-defibrillator troubleshooting (Heart Rhythm Case Reports 2017;3:464–466)

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intervals, increasing the upper tracking rate, and changing the sensing and pacing vectors. Ultimately, reprogramming to Bi-V eliminated TWOS.

Discussion
As with CRT utilizing Bi-V pacing, the goal of LV-only pacing is to reestablish AV synchrony, optimize ventricular contraction, and improve cardiac output. Timing of LV pacing is primarily based on real-time measurements of the intrinsic AV interval, P-wave conduction, and the QRS duration. The pacing algorithm requires the intrinsic heart rate to be less than 100 bpm with a normal AV interval.1,2 Pacing less than 98% of the time has been shown to diminish the therapeutic benefit from CRT.1,2

In this case, the T waves after LV pacing were similar to the intrinsic T waves in morphology, both being 2.5 mm in amplitude in the RV tip–to–RV ring lead in the setting of normal R-wave amplitude (>20 mV). Both were oversensed, leading to inappropriate double counting of ventricular activity and suboptimal pacing (Figure 1). Despite inadequate pacing and no improvement in LV function, the patient remained asymptomatic without signs or symptoms of heart failure, which has been shown to occur in patients with acute reduction in CRT pacing.1

Reprogramming to Bi-V pacing, L>R with a 10 ms delay altered the T-wave morphology and decreased the amplitude of the T wave to 1 mm in the RV tip–to–RV ring lead. This eliminated TWOS and allowed for more reliable pacing (Figure 2). Upon follow-up at 1 month, there was no TWOS with nearly 100% Bi-V pacing and an improvement of LV ejection fraction to 55%. This response highlights the importance of consistent pacing to reestablish mechanical synchrony with CRT.

The deﬁbrillation event was unique in that the intrinsic rate in sinus rhythm was above the upper tracking with intermittent pacing and pseudofusion beats. At higher rates, the T-wave amplitude was increased to 4–5 mm in the RV tip–to–RV ring lead and more often oversensed. The increased intrinsic rate, in combination with TWOS, led to a perceived rate within the VF zone. Morphology for VF was also met by template matching, with >30 of the preceding 40 counts on the electrograms being sensed as VF (Figure 1). There were no further ventricular sensed events upon reprogramming to Bi-V pacing.

To our knowledge, this is the ﬁrst report of TWOS during adaptive LV pacing that was eliminated by switching to Bi-V pacing. Conversely, TWOS occurring with Bi-V pacing and resolving with reprogramming to LV-only pacing has been reported.5,6 Decreasing ventricular sensitivity, decreasing the postventricular atrial refractory period, increasing the tracking rate, and altering the V-V sequence and timing are additional potential reprogramming maneuvers that can be attempted prior to lead revision or generator change.7,8 Here, it was felt that changing to Bi-V pacing was the simplest solution that carried the least amount of risk.

Troubleshooting CRT and implantable cardioverter-deﬁbrillator devices can be technically challenging. We propose another tool for utilization in patients with TWOS during LV-only pacing. This case highlights the need to explore

KEY TEACHING POINTS
- T-wave oversensing can be associated with left ventricular (LV)–only pacing. This can limit pacing and be a reason for nonresponsiveness to cardiac resynchronization therapy with this modality.
- T-wave oversensing during LV-only pacing may also cause inappropriate deﬁbrillation, which places an undue burden on affected patients.
- Reprogramming from LV-only pacing to biventricular pacing may be an option in some patients who experience T-wave oversensing with LV pacing.

Figure 2 Stored electrograms showing T-wave oversensing during adaptive left ventricular (LV) pacing. It is unclear why ventricular sensing did not occur with native conduction (beats 1, 3, and 5) but did occur with LV pacing (beats 2 and 4), despite the similar morphology in this example. Note the change in T-wave morphology and amplitude with reprogramming after the fifth beat. The upper electrogram (EGM) is the atrial activity and the lower strip is the ventricular activity. AS = atrial sense; AR = atrial refractory; VS = ventricular sense; VP = LV pacing; BV = biventricular pacing.
pacing options for each patient to provide optimal, individualized care.

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