FELLOWS CORNER

When logic fails

Justin Phan, MBBS, FRACP,*†‡ Callum Cherrett, MBBS, FRACP,*†
Rajesh Subbiah, MBBS, PhD, FRACP,*†‡ William Lee, MBBS, PhD, FRACP*†‡

*From the *Department of Cardiology, St Vincent's Hospital Sydney, Darlinghurst, Australia, †St Vincent's Clinical School, University of New South Wales, Sydney, Australia, and ‡Victor Chang Cardiac Research Institute, Darlinghurst, Australia.*

A 40-year-old woman with familial dilated cardiomyopathy presents with recurrent episodes of palpitations and presyncope. A primary prevention Cobalt XT dual-chamber implantable-cardioverter defibrillator (ICD) (Medtronic, Minneapolis, MN) had been inserted 1 year prior. A remote monitoring transmission revealed several episodes of device-detected supraventricular tachycardia (SVT) with ICD therapies withheld. Figure 1 demonstrates the intracardiac electrograms from one episode.

During sinus rhythm (As-Vs), the atrial channel electrogram shows a sharp atrial signal followed by a smaller far-field R-wave. This is not sensed by the device during sinus rhythm. A tachycardia begins at the red star and is initiated with a premature ventricular complex. During tachycardia, the far-field R waves are sensed on the atrial channel (red arrows), and there are more ventricular events than true atrial events (blue arrow). This is consistent with ventricular tachycardia (VT); however, the device diagnoses the tachycardia as atrial fibrillation (AF) due to the counting of the far-field R waves and triggers a mode switch.

As the VT continues, the true ventricular and atrial relationship becomes 1:1; however, due to far-field R-wave sensing, the device detects 2 atrial events for each ventricular event, which continues the episode designation as AF. A significant change in the far-field R-wave morphology during VT compared with sinus rhythm likely contributed to the far-field R-wave sensing. Of note, the tachycardia intermittently falls out of the VT zone of 400 ms (as denoted by the Vs instead of Ts markers). The tachycardia then terminates with a premature ventricular complex (Tf) to an atrial paced beat with ventricular safety pacing followed by sinus tachycardia.

Following this episode, the atrial sensitivity was decreased to 0.6 mV from 0.3 mV and the VT detection zone was lowered to 140 beats/min (428 ms) from 150 beats/min. P-wave amplitude in sinus rhythm was 2 mV, which allowed a sufficient margin to avoid P-wave undersensing during sinus rhythm. Initial programming of a VT detection zone of 150 beats/min was done, as the patient had a history of episodes of symptomatic nonsustained VT at 150 to 160 beats/min. Although lowering the VT treatment threshold to 140 beats/min may increase the risk of inappropriate therapy, particularly in a young patient with intact atrioventricular nodal conduction, this was a calculated decision, as undertreatment of VT below the detection limit was thought to be a significant risk. SVT discriminators may ameliorate, but do not eliminate, the risk of inappropriate therapy. VT ablation was discussed as an option, but the patient declined. Following this programming change, all subsequent episodes of VT were correctly identified by the device and no further inappropriate withholding of ICD therapies was observed.

Medtronic ICDs use the PR Logic and wavelet algorithms to discriminate between SVT and VT, which has been shown to result in a low rate of inappropriate tachycardia therapies.[1] The PR Logic algorithm analyzes the timing of atrial and ventricular events to classify tachycardias into AF/atrial flutter, sinus tachycardia, other 1:1 SVT, or double tachycardia (SVT and VT). The PR Logic algorithm uses rate, atrioventricular pattern, regularity, atrioventricular dissociation, AF evidence, and far-field R waves to classify arrhythmias. If there is no classification based on PR Logic, then the QRS waveform–based wavelet feature will be used to determine whether a tachycardia is a true ventricular arrhythmia.[2]

WHAT WE LEARNED FROM THIS CASE

- Despite advances in arrhythmia classification algorithms, misclassifications may still occur.
- Atrial oversensing of ventricular events may occur during tachycardia even when not present during sinus rhythm.
- Increasing atrial sensitivity is one method for managing atrial oversensing of far-field R waves; however, atrial lead repositioning may be considered in refractory cases.

KEYWORDS Defibrillation; Ventricular tachycardia; Supraventricular tachycardia; Inappropriate therapy (Heart Rhythm O2 2023;4:668–670)

Address reprint requests and correspondence: Dr Justin Phan, Department of Cardiology, St Vincent's Hospital Sydney, 390 Victoria Street, Darlinghurst, NSW 2010, Australia. E-mail address: justin.phan@svha.org.au; Twitter: @bringWenckebach.

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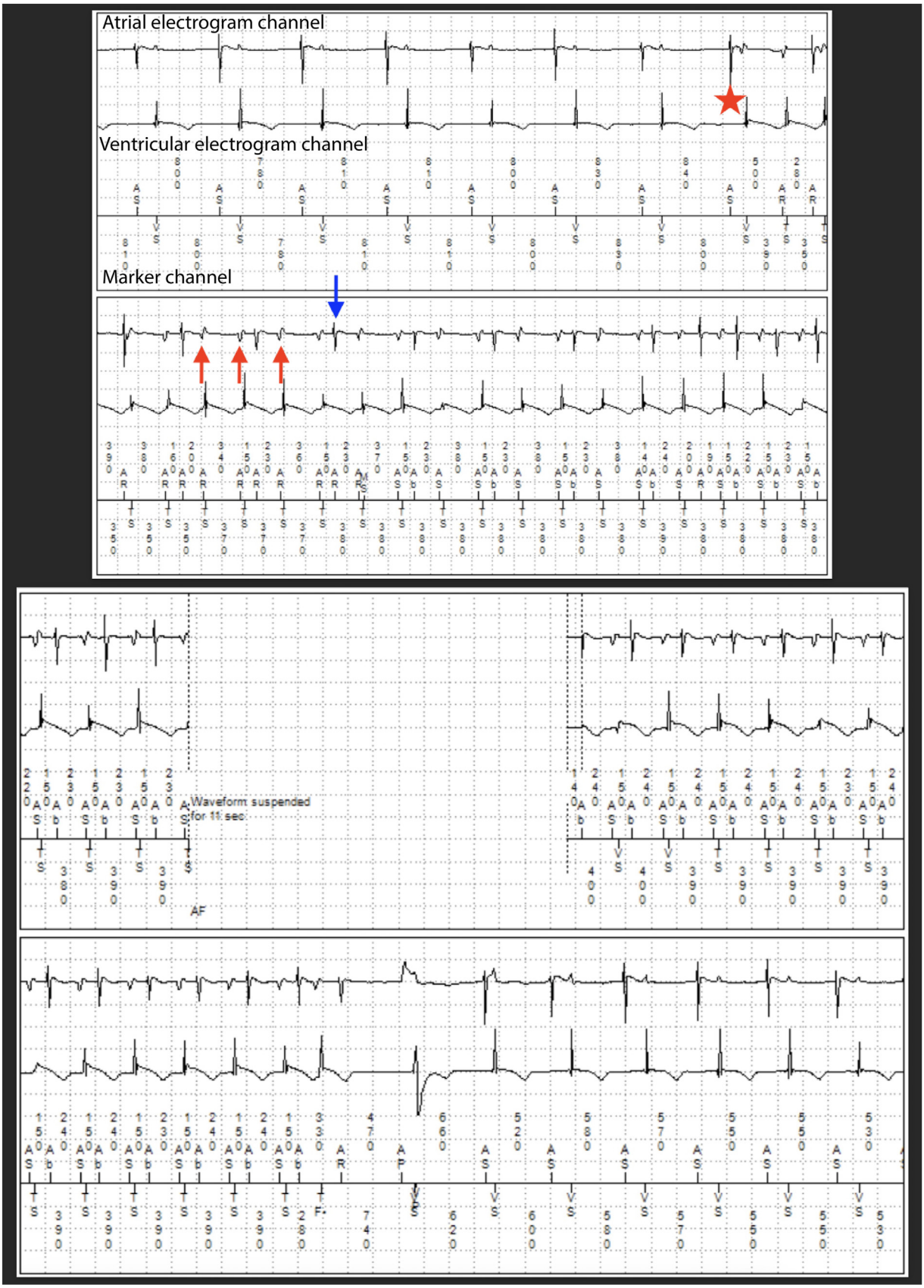

Figure 1 Intracardiac electrograms. The first row shows the atrial channel, the second row shows the ventricular channel, and the third row shows the device markers.

In this case, there is AF evidence, as there are >6 atrial events within the programmed AF detection zone. This triggers the observed mode switch. Classification as double tachycardia does not occur, as this criterion requires the presence of atrioventricular dissociation (irregular A-V and V-A intervals). In this case, during 1:1 tachycardia, the A-V (due to far-field R-wave sensing) and V-A intervals are relatively fixed (regular As-Tf-Ab cycles), thus not fulfilling this criterion. The far-field R-wave algorithm requires far-field R waves and true atrial signals (either sinus or retrograde) to be consistent. However, during the initiation of the VT, there is variable retrograde conduction, which fails to satisfy the criterion for the far-field R-wave algorithm. Finally, during this episode of VT, there are several beats that drop outside of the VT detection zone, which reduces the counter of consecutive intervals used for SVT and VT discrimination.

Decreasing atrial sensitivity prevents R-wave oversensing during episodes of VT, thereby allowing correct detection of the arrhythmia. It is important to ensure that there is an adequate safety margin with the measured P-wave amplitude in sinus rhythm to ensure that P-wave undersensing during sinus rhythm does not occur. Increasing the postventricular atrial blanking period would not be helpful in this case, as the device is already correctly blanking the far-field R-wave (Ab). Repositioning of the atrial lead to a location with a smaller far-field R-wave would be an option; however, this would be associated with increased risk of device surgical complications.

This case highlights an unfortunate combination of factors, including intermittent far-field R-wave sensing (only during VT), variable retrograde conduction during VT, and VT below the detection zone, which ultimately led to misclassification of the arrhythmia as SVT. This episode fortuitously terminated with a premature ventricular complex; however, there is significant risk for undertreatment of VT if no programming changes were made.

Despite significant advances in device algorithms to correctly classify arrhythmias, there may be rare circumstances in which these algorithms fail. Significant work has gone into reducing the risk of inappropriate therapy; however, the risk of underrecognition and undertreatment of ventricular arrhythmias remains. Careful attention to programming and algorithm operation is important in ensuring appropriate detection and treatment of ventricular arrhythmias.

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