

# Inappropriate shock caused by P- and T-wave oversensing in a subcutaneous implantable cardiac defibrillator in a patient in sinus rhythm



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## Introduction

Subcutaneous implantable cardiac defibrillators (S-ICD) are an emerging technology that, in appropriately selected individuals, can be an acceptable alternative to transvenous ICDs (TV-ICD), which can lead to reduced complications associated with lead placement and potential improved durability. S-ICDs have comparable inappropriate discharge rates when compared to TV-ICDs, the cause of which in commonly supraventricular tachycardia (SVT) or T-wave or extracardiac oversensing.<sup>1</sup> While effective and generally safe, TV-ICDs do require placement of TV leads, which are the source of many of the complications. In patients who do not require pacing leads and are considered appropriate on primary electrocardiographic screening, an S-ICD may be an acceptable alternative to a TV-ICD. We present a case in which an S-ICD begins to oversense P waves and T waves in an individual in sinus rhythm, leading to subsequent inappropriate shock, and in which modification of the sensing vector resolved this oversensing.

## Case report

The patient is a 55-year-old white man with past medical history of coronary artery disease status coronary artery bypass graft (RIMA to RPDA, atretic LIMA) and recent ST-elevation myocardial infarction status post percutaneous coronary intervention with DESx2 to the pLAD and DESx1 to the pRamus, paroxysmal atrial fibrillation on apixaban, heart failure with reduced ejection fraction status post TV-ICD placement with multiple pocket site revisions secondary to pocket site discomfort, and subsequent replacement with SICD (Boston Scientific A219 EMBLEM MRI S-ICD) who was recently initiated on home milrinone (ejection fraction: 20%). Prior to S-ICD implantation the patient was

**KEYWORDS** Inappropriate S-ICD shock; Inappropriately sensed P wave; Inappropriately sensed T wave; SICD discharge; Subcutaneous implantable cardiac defibrillator; P-wave oversensing; TWOS; T-wave oversensing (Heart Rhythm Case Reports 2021;7:433–435)

Conflicts of Interest: None. **Address reprint requests and correspondence:** Dr Alexander R. Ochman, Deborah Heart and Lung Center, 200 Trenton Rd, Browns Mills, NJ 08015. E-mail address: [alexanderoc@pcom.edu](mailto:alexanderoc@pcom.edu).

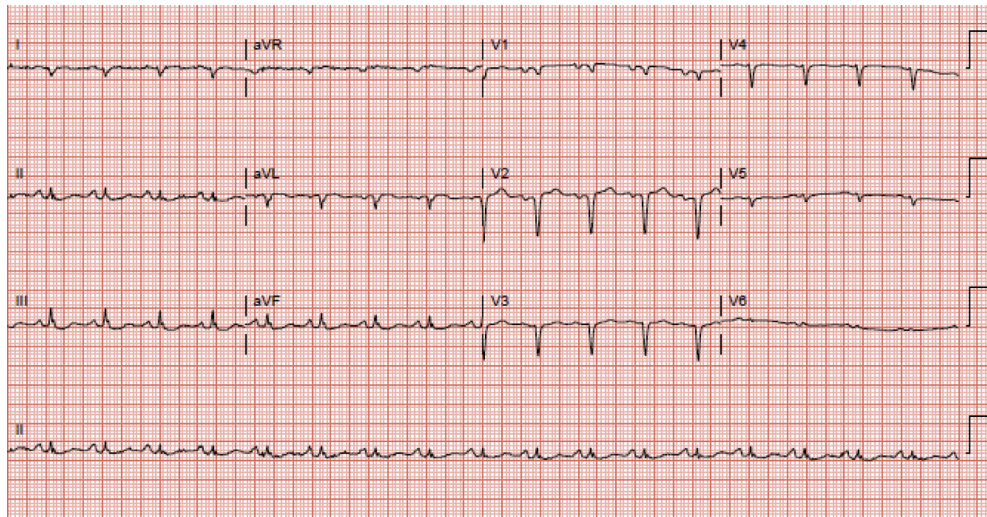
## KEY TEACHING POINTS

- Inappropriate subcutaneous implantable cardiac defibrillator (S-ICD) discharges are known to occur from oversensing of T waves, rapid ventricular rates, and extracardiac noise.
- We report one such case in which an inappropriate shock was initiated from P-wave oversensing in conjunction with QRS and T-wave oversensing.
- Careful screening must be performed with appropriate sensing vector selection in order to avoid atrial oversensing and subsequent S-ICD discharge.

screened both manually and with the automatic sensing tool in the supine position and was deemed appropriate in all 3 sensing vectors for S-ICD implantation. The device was implanted without complication; the primary sensing vector was chosen with SMART Pass filter on. Six months after implantation the patient presented to the emergency department with a chief complaint of a jolt that he felt across his chest that woke him from sleeping. The patient experienced 3 more episodes that evening, prompting him to present to the emergency department (Figure 1). The patient's S-ICD was interrogated (Figure 2). Prior to discharge the patient's sensing vector was modified to the secondary sensing vector with electrogram (Figure 3a, 3b), with no further P- or T-wave oversensing as well as improvement of slewing of QRS complexes. The patient has since had resolution of oversensing with no further S-ICD discharges.

## Discussion

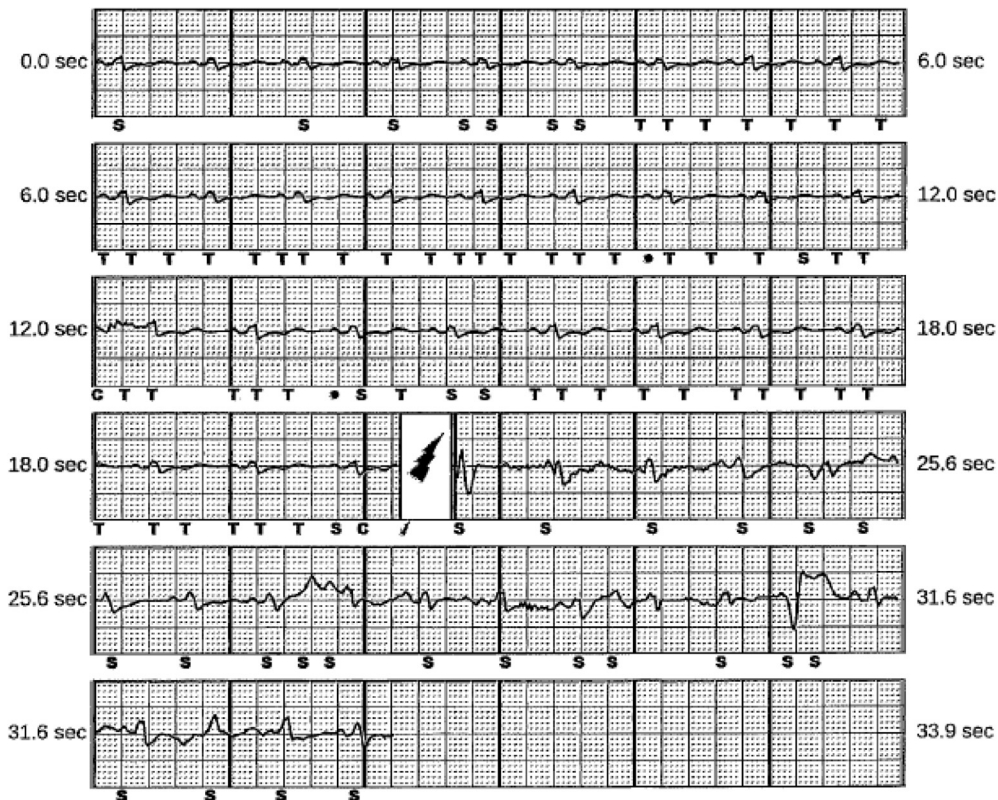
An S-ICD is considered an acceptable alternative to transvenous ICD in patients without a pacemaker indication, with similar efficacy and comparable postimplant complications. S-ICDs have been noted to have improved specificity in discrimination of SVT vs ventricular tachycardia,<sup>2</sup>



**Figure 1** Electrocardiogram in the emergency department revealed sinus tachycardia at a rate of 106 beats/min, left atrial enlargement, poor R-wave progression, right-axis deviation, and low voltage in the limb leads.

with no difference in inappropriate shocks when compared to TV-ICDs.<sup>1</sup> After review of medical literature, we believe this is the first published case report of inappropriate S-ICD shock in P-wave oversensing in a patient without hypertrophic obstructive cardiomyopathy (HOCM).<sup>3,4</sup> It has been proposed that enhanced screening

for atrial enlargement, in consideration of S-ICD selection in hypertrophic cardiomyopathy patients who often have higher-amplitude R waves with a high slew rate, resulting in inappropriate sensing, may be important,<sup>4</sup> but this may also be applicable to other populations. In patients with S-ICDs with low-amplitude QRS complexes, this may also



**Figure 2** Review of the patient’s electrogram (EGM) shows the same morphology of the P, QRS, and T wave at the 0-second mark. Then at 3 seconds of the EGM his P wave and then T wave become sensed, leading to tachycardia detection. This ultimately led to activation of the implantable cardiac defibrillator and the patient was shocked. After discharge the patient remained in sinus rhythm with intermittent oversensing of his T wave, but it did not meet the threshold for tachycardia detection.



**Figure 3** a: The patient's presenting sensing electrogram (EGM) vector. Note larger P waves and slewed QRS; the conditional zone was set at 180 beats/min (bpm) and shock zone at 240 bpm. b: The patient's modified sensing vector with new conditional shock zone setting of 200 bpm and shock zone of 250 bpm. As can be seen within the new EGM, P-wave, QRS, and T-wave morphology are distinctly different.

lead to T-wave and P-wave oversensing if a decrease in QRS amplitude occurs, which may lead to oversensing; therefore, sensing vector, appropriate device placement, and device selection becomes even more important. Our patient had developed both P- and T-wave oversensing, resulting in S-ICD discharge, after meeting initial screening criteria, but does not have HOCM as noted in prior cases of P-wave oversensing.<sup>3,4</sup> The literature reports that the rate of S-ICD vs TV-ICD inappropriate shocks is not statistically significant. Meta-analysis reports inappropriate shock rate at 8.3% in S-ICDs and 9.46% in TV-ICDs.<sup>1</sup> It was further noted that inappropriate TV-ICD shocks were roughly 10 times more likely to be caused by SVT and atrial fibrillation, where inappropriate S-ICD shocks were roughly 9 times more likely to be caused by cardiac oversensing.<sup>1</sup> Given the inappropriate sensing of both P and T waves, the sensing vector was modified with resolution of inappropriate sensing. With review of the patient's chart, P-wave and T-wave morphology amplitude and axis were unchanged within the implantation-to-presentation timeframe. To our knowledge, inappropriate oversensing of P in conjunction with T waves resulting in S-ICD firing has not been previously described in the literature in patients without HOCM. Further, as with oversensing of

T waves, appropriate selection of sensing vector to reduce the incidence of P/T-wave oversensing is imperative.

## Conclusion

We present a case in which a patient received inappropriate S-ICD therapy secondary to P-wave in conjunction with T-wave oversensing in a patient with sinus rhythm, which has not been previously described in the literature. It is known that T-wave oversensing is one of the most common causes of inappropriate shocks in patients with S-ICD, but in select populations appropriate selection of sensing vectors to avoid P-wave oversensing may be imperative to avoid inappropriate S-ICD discharges.

## References

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