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Two Limitations of Subcutaneous Implantable Cardioverter Defibrillator in the Same Patient Warranting Its Explant

Authors' Contribution:
Study Design A
Data Collection B
Statistical Analysis C
Data Interpretation D
Manuscript Preparation E
Literature Search F
Funds Collection G

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Conflict of interest: None declared

Patient: Male, 50-year-old
Final Diagnosis: Ventricular tachycardia
Symptoms: Lightheadedness • palpitation • shocks by implantable cardioverter defibrillator
Medication: Amiodarone • sotalol • mexiletine
Clinical Procedure: Implantation of subcutaneous implantable cardioverter defibrillator (S-ICD) • implantation of transvenous implantable cardioverter defibrillator (TV-ICD) • ablation of ventricular tachycardia • explantation of S-ICD • incision and drainage of S-ICD pocket site infection
Specialty: Cardiology • Cardiac Electrophysiology

Objective: Unusual clinical course

Background: A subcutaneous implantable cardioverter defibrillator (S-ICD) is preferred over a transvenous implantable cardioverter defibrillator (TV-ICD) in selected cases owing to a lower rate of lead-related complications such as infections and venous thrombosis. However, the S-ICD has its own limitations, including inappropriate shocks due to oversensed events, and the inability to treat ventricular tachycardia (VT) below a heart rate of 170 beats per minutes (bpm). We present a patient case which showed manifestations of both of these limitations, warranting explant of the device.

Case Report: A 50-year-old man with a history of nonischemic cardiomyopathy and VT had a S-ICD placed at an outside facility. However, he continued to have VT despite on anti-arrhythmic drugs and required recurrent S-ICD shocks. Device interrogation showed that he was intermittently receiving appropriate shocks for slower VT (with a heart rate ranging from 150 bpm to 160 bpm) due to oversensing of T waves. However, treatment was delayed for other VT episodes owing to appropriate sensing and the patient's heart rate being below the lowest detection zone for S-ICD. Due to slower VT cycle length and frequent oversensed events, the S-ICD was ultimately replaced by a TV-ICD system.

Conclusions: This case report emphasizes the importance of S-ICD pre-implant vector screening and the need for paying attention to VT cycle length to prevent inappropriate device shocks and/or delayed therapies.

Keywords: Cardiac Electrophysiology • Subcutaneous ICD • Transvenous ICD • Oversensing • Ventricular Tachycardia

Full-text PDF: https://www.amjcaserep.com/abstract/index/idArt/928983

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Background

The subcutaneous implantable cardioverter defibrillator (S-ICD) was approved by the FDA in 2012 [1]. It works in 3 phases: a detection phase, certification phase (to remove oversensed events), and therapy decision phase, during which shock is delivered [1]. Although the S-ICD has certain advantages over a transvenous implantable cardioverter defibrillator (TV-ICD), it has limitations, including the inability to treat ventricular tachycardia (VT) below a heart rate of 170 beats per minute (bpm), oversensing that can result in inappropriate shocks (especially if not screened properly), and a lack of pacing capability. A study by Noel et al estimated oversensed events in 16% of S-ICD recipients, and 5.6% of the patients underwent device extraction due to the oversensed events [2]. We present an interesting case [3] of intermittent T-wave oversensing that led to intermittent appropriate S-ICD therapy for VT below a heart rate of 170 bpm, which was untreated at other times because of appropriate sensing.

Case Report

A 50-year-old man with a history of nonischemic cardiomyopathy (left ventricular ejection fraction of 25%) and VT had an S-ICD placed in December 2018 at an outside hospital. His

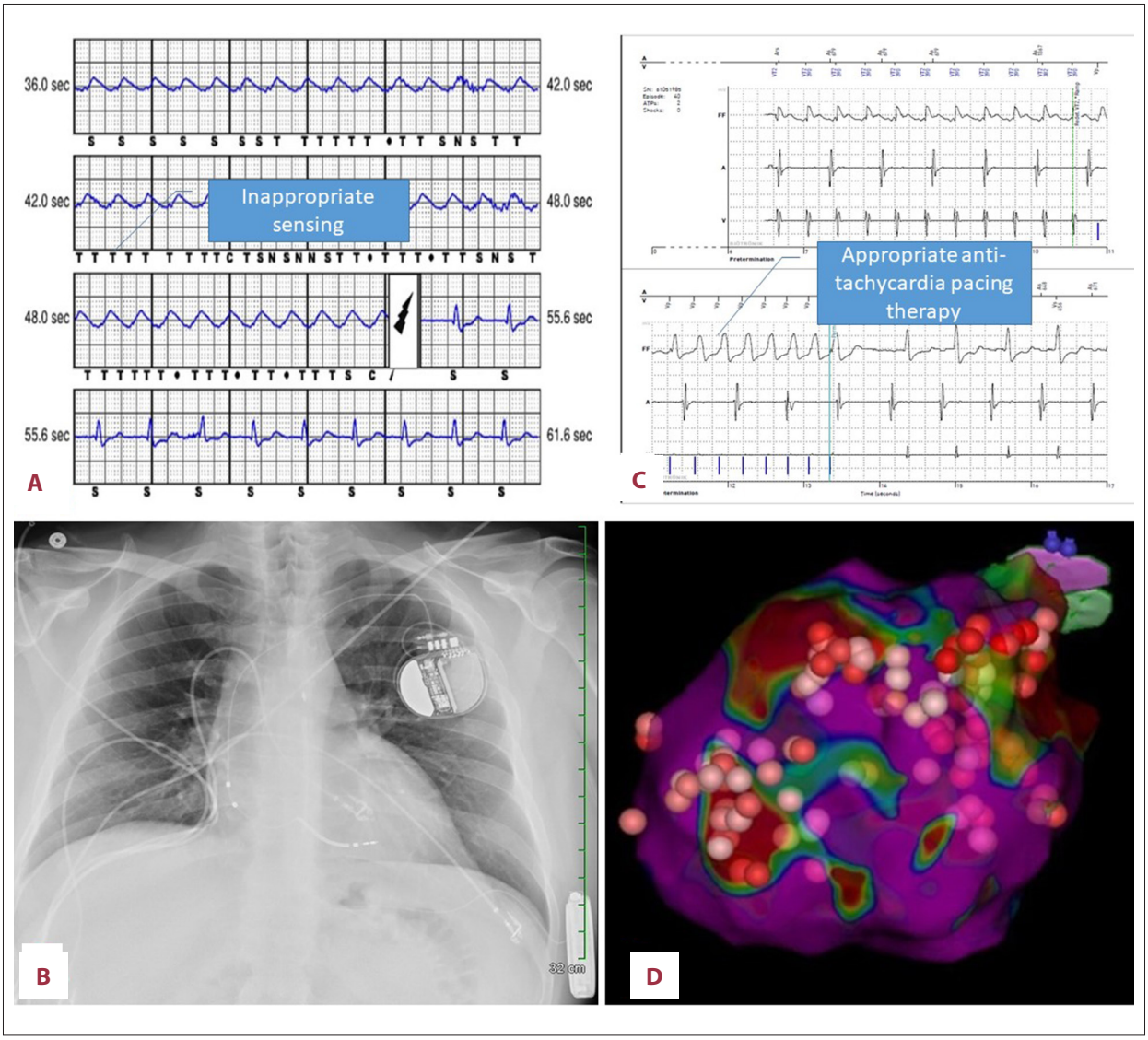

Figure 1. (**A**) Subcutaneous implantable cardioverter defibrillator (S-ICD) interrogation showing inappropriate T-wave oversensing leading to appropriate shock by the device. (**B**) Chest X-ray prior to S-ICD removal showing newly implanted transvenous implantable cardioverter defibrillator (TV-ICD). (**C**) TV-ICD with appropriate sensing leading to appropriate therapy. (**D**) Electroanatomic map of left ventricle in left lateral view showing ablation points in basal to mid anterolateral wall.

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Table 1. Timeline.

At presentation	S-ICD was placed at outside hospital for secondary prevention
6 months	Patient started having recurrent S-ICD shocks and was started on anti-arrhythmic medications
8 months	Patient was transferred to our hospital for recurrent VT and S-ICD shocks
8 months	TV-ICD was implanted and S-ICD was turned off
11 months	VT ablation was done
12 months	S-ICD was explanted
14 months	Pocket site infection occurred at S-ICD site requiring incision and drainage, along with a short course of antibiotics
26 months	Patient was followed up in clinic, with no additional delayed or inappropriate TV-ICD therapy found

S-ICD – subcutaneous implantable cardioverter defibrillator; TV-ICD – transvenous implantable cardioverter defibrillator; VT – ventricular tachycardia.

symptoms during VT were palpitations and lightheadedness. He started having multiple S-ICD shocks 6 months after the S-ICD implantation. He was administered amiodarone, which had to be discontinued due to pulmonary toxicity. Treatment with sotalol and mexiletine were initiated; however, the patient continued to have recurrent VT and S-ICD shocks. He was transferred to our hospital in July 2019 for further management. Device interrogation on admission showed one VT event, which was appropriately detected and treated. However, all other VT events were in the heart rate range of 150 bpm to 160 bpm. This was under the lowest detection zone of S-ICD therapy (which is 170 bpm), but VT was inappropriately detected due to the oversensing of T waves (despite having a SMART Pass filter on) leading to appropriate S-ICD shocks (**Figure 1A**). There were, however, additional events where the device did not treat slow VT (heart rate around 150-160 bpm) due to appropriate sensing, leading to the absence or delay of therapy.

Due to recurrent slow VT, intermittent oversensing of T waves, and the limitation of the S-ICD detection zone to appropriately treat all VT episodes, we decided to explant the S-ICD. The patient underwent a single chamber TV-ICD implant in July 2019, and the S-ICD was turned off. Because recurrent symptomatic slow VT was appropriately detected and successfully treated with anti-tachycardia pacing by the TV-ICD system (**Figure 1C**), the patient underwent VT ablation in October 2019 (3 months after the TV-ICD implant and 1 month before the S-ICD explant). Substrate modification and local abnormal ventricular activity ablation was successfully performed in the basal to mid anterolateral wall of the left ventricle (**Figure 1D**). Treatment with mexiletine was discontinued after the ablation procedure, and sotalol was continued. The staged removal of the S-ICD was done in November 2019 (**Figure 1B**). Unfortunately, the S-ICD extraction was complicated by delayed pocket site infection requiring incision and drainage (I&D) and a short course of antibiotics 2 months after the S-ICD explantation.

The patient had routine follow-up visits in arrhythmia clinic, with the last visit occurring 15 months after his ablation procedure. During this visit, no additional delayed or inappropriate TV-ICD therapy was found. The patient's treatment timeline is shown in **Table 1**.

Discussion

There has been an increase in the use of the S-ICD to minimize complications associated with the presence of a TV-ICD system, such as systemic infections, venous obstruction, and thrombosis [4]. A meta-analysis comparing TV-ICD and S-ICD systems showed fewer lead-related complications in the S-ICD group; however, it reported a similar infection rate in both groups. The incidence of inappropriate shocks was similar in both groups, but the TV-ICD group had inappropriate shocks primarily due to treatment of supraventricular tachycardia, whereas oversensing of T waves or noise resulted in inappropriate shocks in the S-ICD group [5]. However, none of the studies included in the meta-analysis were randomized. Only 1 randomized study compared the S-ICD and TV-ICD. That trial showed a higher trend of inappropriate shocks in the S-ICD group, which were mostly related to the oversensing of T and P waves or extracardiac stimuli, such as myopotentials and noise. However, the trial did not have sufficient power for this outcome [6]. Importantly, inappropriate therapies of TV-ICD are usually due to supraventricular tachycardia, which can be managed easily by reprogramming the device. However, in the S-ICD, there are limited options for managing inappropriate shocks due to oversensing [6]. There is a definite need for further studies to delineate the difference in inappropriate

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shocks between the 2 devices. Young patient age, small amplitude of QRS complexes, atrial fibrillation, and hypertrophic cardiomyopathy have been associated with T-wave oversensing [7,8]. Manual and automated screening tools lack specificity to select eligible patients [9,10]. The SMART Pass filter has helped reduce oversensing events [11]; however, it does not eliminate the risk of inappropriate shocks. In addition, a sensing vector may be appropriate at the time of device implantation, but it is dynamic and can result in a poor quality vector over time [2]. A rate-dependent bundle branch block can also lead to inappropriate sensing due to double counting of the notched R wave [2]. The evaluation of factors impacting clinical outcome and cost effectiveness of the S-ICD (EFFORTLESS S-ICD) registry showed that the 1-year complication rate of the S-ICD was 2%, with an inappropriate shock incidence of 1.5% [12]. Because of the potential issues of oversensing, vigilant pre-implant screening is needed. The S-ICD is also not ideal for slow ventricular arrhythmias owing to its limitations of arrhythmia detection zone and treatment [2].

Our case describes a scenario in which appropriate screening and selection of the suitable defibrillator type to treat slower VT could have potentially avoided 3 procedures (S-ICD implantation, followed by its extraction, and then its pocket site I&D). It would have reduced the healthcare costs and improved the patient outcomes.

Conclusions

Both the S-ICD and TV-ICD have limitations. This case highlights 2 limitations of the S-ICD that hindered appropriate management of this patient's VT, resulting in his S-ICD being replaced with a TV-ICD for appropriate management. Available options for managing the oversensing problems of the S-ICD are limited; therefore, extra diligence is needed during pre-implant vector screening. The dynamic nature of this vector should also be considered prior to device implantation. Due to SICD's limitation to treat slower VT (tachycardia cycle length less than 170 bpm); close attention should be paid to the clinical VT cycle length prior to S-ICD implantation to avoid absence or delay of appropriate device therapies.

Conflicts of Interest

None.

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