Impact of a novel algorithm designed to reduce T-wave oversensing with the subcutaneous defibrillator in a patient with type I Brugada electrocardiogram

Serge Boveda, MD,* Marijke C. Laarakker, PhD,† Christèle Cardin, MD,* Jean-Paul Albenque, MD*

*From the *Cardiac Arrhythmias Management, Cardiology Department, Clinique Pasteur, Toulouse, France, and †Boston Scientific Europe, Paris, France.*

Introduction

Brugada syndrome (BrS) is an inherited disease associated with an increased risk of developing malignant ventricular arrhythmias. These can not only cause syncope but also lead to sudden cardiac death (SCD), which may be the first manifestation of the syndrome. The type I electrocardiogram (ECG) is typically characterized by ST-segment elevation of more than 2 mm (coved type) in at least one of the right precordial leads.[1,2] The most common gene mutation is associated with the *SCN5A* locus and found in 20%–25% of patients with BrS.[3,4]

While implantable cardioverter-defibrillator (ICD) therapy is the main therapy in symptomatic patients,[5] a low arrhythmic event rate is often observed and the relatively high complication risk in mostly young patients who receive transvenous ICDs (TV-ICDs) should be taken into account when considering this approach.[6] Common complications in these patients are inappropriate shocks,[7] mainly due to T-wave oversensing, caused by spontaneous ECG variability, which increases the risk of false detection.[8,9]

Despite its existing detection algorithms, the morphology-based subcutaneous sensing approach of the subcutaneous ICD (S-ICD) has been vulnerable to QRS/T-wave oversensing, which is the leading cause of inappropriate shocks with the S-ICD.[10] This phenomenon occurs more often in patients with spontaneous type I Brugada ECGs.[5,11,12]

Conversely, many of the system-related complications of TV-ICDs can be avoided by the S-ICD: with a device-related complication–free rate of 99%[13] and which is considered a favorable therapy, over TV-ICD therapy, in young patients.[14]

KEYWORDS Brugada syndrome; Detection algorithms; Inappropriate shocks; Subcutaneous defibrillator; T-wave oversensing
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Dr Boveda serves as a consultant to Boston Scientific, Medtronic, and Livanova. Dr Laarakker is a Boston Scientific employee. Dr Albenque serves as a consultant to Abbott and Biosense Webster. **Address reprint requests and correspondence:** Dr Serge Boveda, Cardiac Arrhythmias Management, Cardiology Department, Clinique Pasteur, 45, Avenue de Lombez, 31076 Toulouse, France. E-mail address: sboveda@clinique-pasteur.com.

KEY TEACHING POINTS

- Common complications in patients with Brugada syndrome are inappropriate shocks, mainly due to T-wave oversensing, caused by spontaneous electrocardiogram (ECG) variability, which increases the risk of false detection.
- The morphology-based subcutaneous sensing approach of the subcutaneous implantable cardioverter-defibrillator (S-ICD) has been vulnerable to QRS/T-wave oversensing, which is the leading cause of inappropriate shocks with the S-ICD.
- The SMART Pass algorithm enables a high-pass (9-Hz) filter for sensing and heart rate estimate. This algorithm seems to be particularly attractive for reducing inappropriate shocks in patients with dynamic ECG morphology changes, like in Brugada syndrome.
- This patient case underscores the clinical value of S-ICD as an alternative solution for younger patients, who need multiple years of ICD therapy, for sudden cardiac death prophylaxis.

Case report

In 1998, a 37-year-old male patient with a family history of BrS (brother experienced resuscitated cardiac arrest and underwent ICD implantation), spontaneous type I ECG (Figure 1), and ventricular fibrillation induction during electrophysiology study was implanted with a single-chamber TV-ICD for the primary prevention of SCD.

Electrical storm occurred in 2005 for which the patient received 10 appropriate ICD shocks and was subsequently treated with quinidine without arrhythmia relapse.

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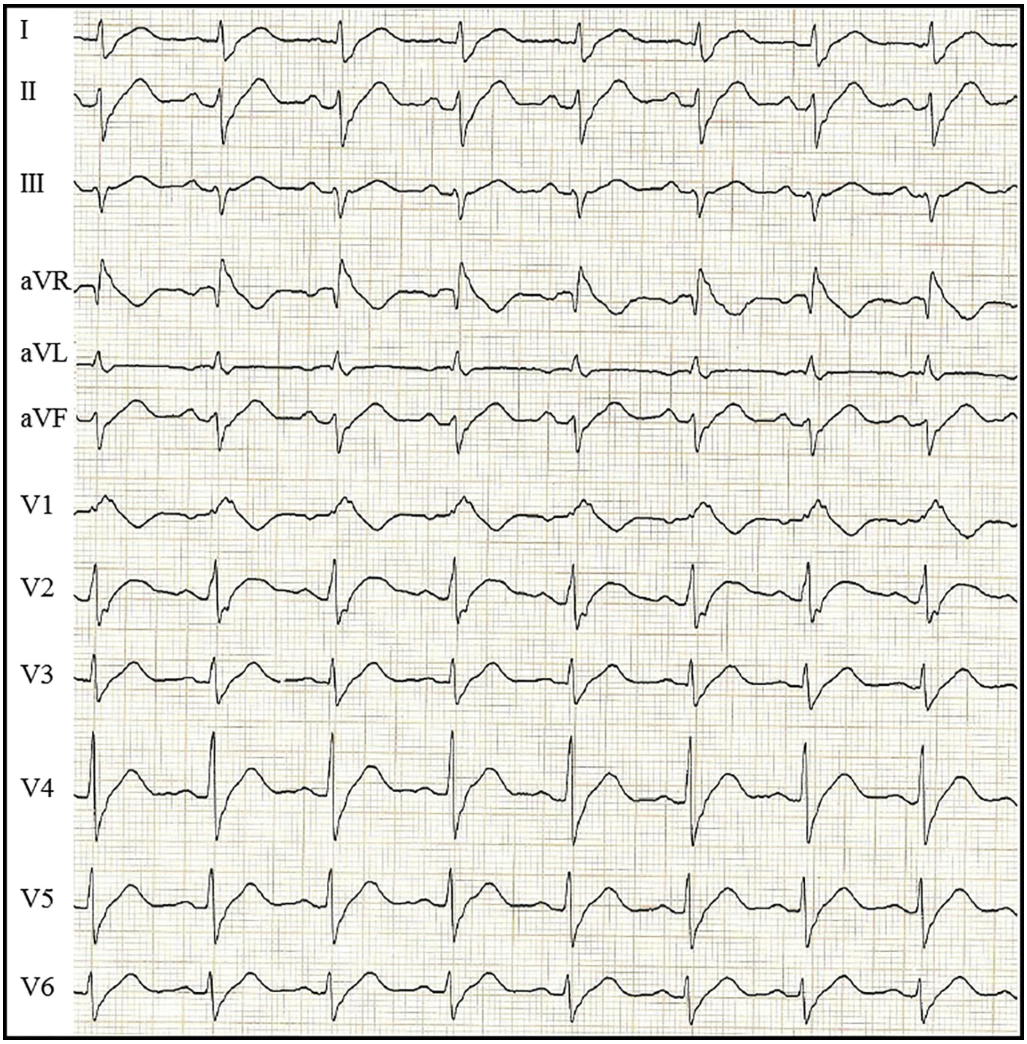

Figure 1 Surface electrocardiogram: observe the spontaneous marked ST-segment elevation in lead V_1 in this patient.

In July 2015, the patient was diagnosed with a severe *Staphylococcus aureus* infection, including valvular endocarditis, septic pulmonary embolism, and cardiogenic shock. This was preceded by a problematic history over 12 years, including 3 device replacements, of which 2 were elective due to battery depletion. In addition, 2 right ventricular leads were replaced owing to mechanical lead failure. In total, there were 4 surgical interventions, including 1 successful lead extraction. After complete system extraction in July 2015, the patient was offered a wearable defibrillator while he remained under antibiotic treatment for 6 weeks to resolve his valvular endocarditis.

Considering the considerable burden of complications in this still young patient, and despite a type I ST-segment elevation on the surface ECG (Figure 1), an EMBLEM S-ICD (model A209, Boston Scientific, SW 3.0.479) was implanted in September 2015. The implantation procedure was uneventful, with a successful defibrillation conversion test at 65 J. Two suitable sensing vectors (secondary and alternate) could be identified, albeit with borderline small signals of 0.4 mV or less.

In the period between November 2015 and June 2016, there were 8 untreated and 1 treated episodes due to T-wave oversensing. These episodes typically occurred at heart rates above 90 beats/min. Furthermore, there was evidence of multiple events of inappropriately sensed but correctly discarded T waves by the morphology correlation and double detection algorithm of S-ICD.

In June 2016, the device was upgraded with a new software version (SW 3.1.529), including the SMART Pass algorithm, which uses a digital high-pass (9-Hz) filter in the sensing circuit of the S-ICD to avoid cardiac oversensing. In the subsequent year, no episodes of T-wave oversensing or discarded T waves occurred, even during exercise-induced heart rates above 100 beats/min. Switching SMART Pass on clearly resulted in a reduction in discarded T waves,

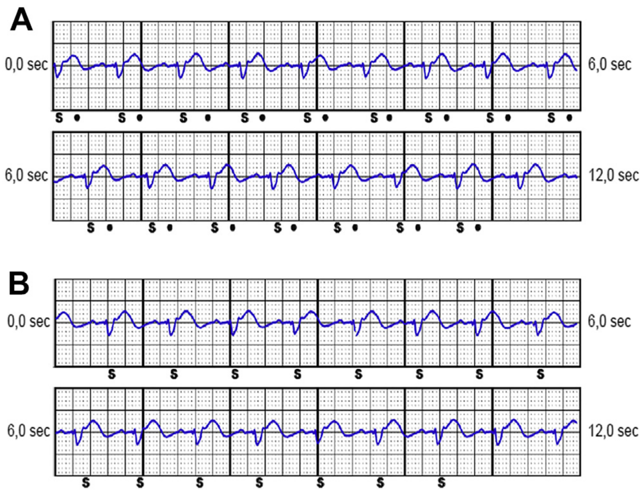

Figure 2 **A:** Inappropriately sensed but correctly discarded T waves (*black dots*) with SMART Pass off. **B:** In the same patient, T waves are no longer sensed with SMART Pass on and with the same sensing vector (secondary configuration). S = ventricular sensing.

which are no longer sensed when the algorithm is active (Figure 2).

Discussion

With this case report of a patient with BrS and a dynamic type I ECG morphology, we sought to illustrate the impact of a novel algorithm (SMART Pass, Marlborough, MA) designed to avoid oversensing of the low-amplitude cardiac signals and demonstrate the suitability of S-ICD in these patients.

The SMART Pass algorithm enables a high-pass (9-Hz) filter for sensing and heart rate estimate. The ECG for rhythm discrimination remains unchanged and continues to use the wide-band filtered ECG similar to previous generations. SMART Pass will be enabled with manual/automatic setup during a session (QRS voltage >0.5 mV) and will be automatically disabled for low amplitudes and slower rates.

Conclusion

This patient case underscores the clinical value of S-ICD as an alternative solution for younger patients, who need multiple years of ICD therapy, for SCD prophylaxis. The SMART Pass algorithm seems to be particularly attractive for reducing inappropriate shocks in patients with dynamic ECG morphology changes, like in BrS.

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