T-wave oversensing during drug challenge test after subcutaneous implantable cardioverter-defibrillator implantation in a patient with Brugada syndrome

Tsukasa Kamakura, MD, PhD, Taiki Sato, MD, Mitsuru Wada, MD, Kohei Ishibashi, MD, PhD, Takashi Noda, MD, PhD, Kengo Kusano, MD, PhD

From the Division of Arrhythmia and Electrophysiology, Department of Cardiovascular Medicine, National Cerebral and Cardiovascular Center, Suita, Japan.

Introduction

The subcutaneous implantable cardioverter-defibrillator (S-ICD) is an effective alternative to the conventional transvenous ICD (TV-ICD) system in patients that can be employed without the need for antitachycardia or antibrady-cardia pacing.1,2 Because the risk associated with a TV-ICD increases over time,3 populations in which there may be a preference for an S-ICD include younger patients, those with channelopathies, and those at high risk of complications with a TV-ICD.

Brugada syndrome (BrS) is an arrhythmogenic disease that mainly affects middle-aged men and causes sudden cardiac death owing to ventricular fibrillation. Whereas ICD implantation is considered the main therapy in symptomatic patients, the TV-ICD has been associated with high complication rates in BrS patients implanted with an ICD.4 The S-ICD is an appealing alternative choice for BrS patients. However, the Brugada-pattern electrocardiogram (ECG) is known to show dynamic changes, and the accuracy of ECG discrimination is a concern with S-ICD implantation in patients with BrS. A drug challenge test may serve as a useful screening tool for patient eligibility to receive an S-ICD. Here, we report a case of T-wave oversensing (TWOS) during a drug challenge test after S-ICD implantation in a patient with BrS.

Case report

A 51-year-old man with BrS was referred to our hospital in consideration for ICD implantation. His baseline ECG showed a spontaneous type 1 ECG in lead V1 in the third intercostal space (Figure 1A). Although the patient had no episodes of cardiac arrest or syncope, he had a strong family history of sudden cardiac death (his grandmother and cousin died suddenly during sleep at the ages of 48 and 31, respectively). No cardiac abnormality was observed by transthoracic echocardiography, and a standard 12-lead ECG was normal except for incomplete right bundle branch block (Figure 1A). Implantation of an S-ICD was considered because ventricular fibrillation was induced in an electrophysiological study. Screening for S-ICD sensing in a standard left parasternal lead position showed adequate sensing in all 3 sensing vectors in both standing and supine positions (Figure 2A). The S-ICD (EMBLEM; Boston Scientific, Marlborough, MA) was successfully implanted on the left side of the thorax using a standard technique (Figure 1B).

On the day following S-ICD implantation, only a type 2 Brugada-pattern ECG was observed in the baseline ECG, even in high costal ECG recordings (Figure 1C). A screening ECG still showed adequate sensing in vector III (Figure 2B). The other sensing vectors (I, II) were not acceptable owing to high amplitude of T waves. Interrogation of the S-ICD revealed appropriate sensing with no TWOS in either standing or supine positions in all sensing vectors (Figure 3A).

Following injection of 50 mg of pilsicainide (class IC antiarrhythmic agent), a type 1 ECG was recorded in lead V1 in the second intercostal space (Figure 1D). A screening ECG still showed adequate sensing in vector III (Figure 2C). However, TWOS was observed in the primary vector of the S-ICD electrogram (corresponding to vector III in the screening ECG), which did not result in tachycardia detection or inappropriate shocks (Figure 3B). Isoproterenol
infusion was followed by pilsicainide injection (Figure 1E), but all sensing vectors were unacceptable owing to augmentation of the T waves (Figure 2D). TWOS was still observed, but only in the primary vector of S-ICD recorded in the supine position (Figure 3C). No appropriate or inappropriate shocks have occurred for up to 1 month after S-ICD implantation.

**Discussion**

To date, the significance of the drug challenge test as a screening tool before S-ICD implantation in BrS remains unknown. Although all sensing vectors were appropriate during preimplant screening in this patient, only 1 vector was acceptable on the day following S-ICD implantation; furthermore, this became unacceptable after the drug challenge test with pilsicainide and isoproterenol, and led to TWOS in the S-ICD recording. Our report demonstrates that the drug challenge test may be useful in evaluating the appropriateness of S-ICD indication in those patients with BrS.

The Brugada-pattern ECG is prone to dynamic ECG changes, and is unmasked by a provocation test with sodium-channel blockers; this may lead to inadequate sensing of the S-ICD system by changes in the QRS/T ratio. TWOS is one of the main causes of inappropriate shocks in patients implanted with an S-ICD. Preimplant screening utilizing surface electrodes is effective only if a single lead consistently falls within the designated area throughout a 10-second period in both supine and standing positions. Screening tests conducted only at rest may be inadequate for the prediction of the TWOS in S-ICD candidates with BrS. This is because ST-segment augmentation in the right precordial leads is observed in various daily life situations such as during sleep, following a meal, after exercise, and

**Figure 1**  
A: In the baseline electrocardiograms (ECGs) of this 51-year-old male patient, type 1 ECG was observed only in lead $V_1$ in the third intercostal space.  
B: The pulse generator was placed subcutaneously in the middle axillary line with the electrode inserted subcutaneously parallel to the sternal midline.  
C: One day after subcutaneous implantable cardioverter-defibrillator (S-ICD) implantation, only type 2 Brugada-pattern ECGs were observed including in the high costal ECG recordings.  
D: After 50 mg pilsicainide injection, type 1 ECG appeared in lead $V_1$ in the second intercostal space.  
E: Isoproterenol infusion was followed by pilsicainide injection, and the amplitude of the J-point in the right precordial leads decreased.
in the febrile state. To date, the morphology of ECG templates of sensing vectors derived from repeated ECG recordings and drug challenge tests have not been evaluated. This study provides important information in that the appropriate sensing vectors can change day-to-day, or owing to drug provocation testing in patients with BrS. TWOS by the S-ICD can occur after a drug challenge test with pilsicainide/isoproterenol, or under conditions that cause similar ECG changes in patients with BrS. A preimplant drug challenge test may be applicable even in patients with a spontaneous type 1 ECG. Furthermore, a considerable number of patients with early repolarization syndrome are reported to show a Brugada-pattern ECG only in the high intercostal spaces. Drug challenge tests may also be useful for prediction of TWOS in those S-ICD candidates with lethal arrhythmic disorders such as early repolarization syndrome. The QRS/T ratio also changes during exertion, and TWOS is often associated with exercise in patients fitted with an S-ICD. The importance of obtaining sensing templates during exercise testing prior to implantation has been demonstrated. In the present study, the amplitude of T waves in the screening ECGs increased after isoproterenol infusion (Figure 3D), and previously appropriate sensing vectors were no longer acceptable. The isoproterenol infusion test can be an alternative to exercise screening.

This patient has not experienced inappropriate shocks due to TWOS after implantation. A new S-ICD sensing algorithm that uses correlation of the existing complex to previous complexes was reported to reduce the number of inappropriate episodes due to TWOS by approximately 30%–40% without compromising detection of ventricular arrhythmias. Further follow-up is needed to evaluate the significance of the drug challenge test in patients with BrS.

**Conclusions**

Drug challenge testing with pilsicainide and isoproterenol unmasked an unsuitable BrS patient formerly thought to be eligible for S-ICD implantation at baseline. Our report demonstrates that the drug challenge test may be useful in evaluating the appropriateness of an indication for S-ICD in patients with BrS.
References


Figure 3  A: Subcutaneous implantable cardioverter-defibrillator (S-ICD) recording showed normal sensing in the baseline 1 day after implantation. B: After 50 mg of pilsicainide injection, T-wave oversensing (TWOS) (red arrow) appeared in the primary vector, corresponding to vector III in the screening electrocardiogram. C: TWOS was still observed after isoproterenol infusion in the primary vector in the supine position. TWOS observed after pilsicainide and isoproterenol infusion did not result in tachycardia detection. Primary, secondary, and alternate vectors of the S-ICD electrogram correspond to vectors III, II, and I of the screening electrocardiogram, respectively. S = sensed ventricular event in the normal heart rate range.