Inappropriate shock from delayed T-wave oversensing by a subcutaneous implantable cardioverter-defibrillator after septal myectomy for hypertrophic cardiomyopathy

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Introduction

Subcutaneous implantable cardioverter-defibrillators (SICD) are effective for primary prevention in patients with hypertrophic cardiomyopathy (HCM), and proper screening can prevent oversensing despite significant left ventricular hypertrophy. Invasive treatment for HCM, however, may change the underlying substrate and impact appropriate SICD screening.

Case report

A 46-year-old man with midcavitary-type HCM underwent SICD (Emblem S-ICD model A209, Boston Scientific, Marlborough, MA) implantation on May 2016 for primary prevention of sudden cardiac death after event monitoring showed several episodes of nonsustained ventricular tachycardia and cardiac magnetic resonance demonstrated patchy late gadolinium enhancement noted in the basal anterior, basal anteroseptum, and left ventricular apex. The primary sensing configuration was used with SMARTPASS off. He continued to be symptomatic (frequent near-syncopal episodes and known hypotensive response with stress exercise) despite maximally tolerated medical therapy and underwent septal myectomy at another institution in June 2017. Preoperative electrocardiogram (ECG) showed sinus rhythm, left atrial enlargement, and left axis deviation with a QRS duration of 88 ms (Figure 1A). Postoperatively, he developed third-degree atrioventricular block, which required temporary pacing but which subsequently resolved. His recovery was otherwise uncomplicated. He did develop left bundle branch block (LBBB) following myectomy (Figure 1B). No changes were made in SICD sensing vector at discharge following myectomy. A follow-up ECG 39 days post-surgery showed persistent LBBB but taller T waves compared to the ECG obtained immediately postoperatively (Figure 2).

On October 2017, he presented to an outside hospital with complaints of irregular heartbeat and multiple ICD shocks. He reported missing a dose of metoprolol that day. Device interrogation showed sinus tachycardia and inappropriate shocks owing to T-wave oversensing (TWOS) (Figure 3). The device was updated with the new ECG template (SMARTPASS) and the sensing vector configuration was changed from primary to alternate. TWOS resolved and the patient has had no further recurrence since then.

KEY TEACHING POINTS

- Subcutaneous implantable cardioverter-defibrillators (SICDs) are effective for prevention of sudden cardiac death in patients with hypertrophic cardiomyopathy (HCM).
- New conduction abnormalities, especially left bundle branch block, may develop in HCM patients following septal reduction surgery and can result in T-wave oversensing (TWOS). Immediate interrogation of the SICD with update of templates following surgery is recommended.
- Close monitoring of SICD sensor settings for up to several months after invasive treatment for HCM is suggested to identify TWOS and avoid inappropriate shocks.

KEYWORDS Hypertrophic cardiomyopathy; Left bundle branch block; Septal myectomy; SICD; T-wave oversensing
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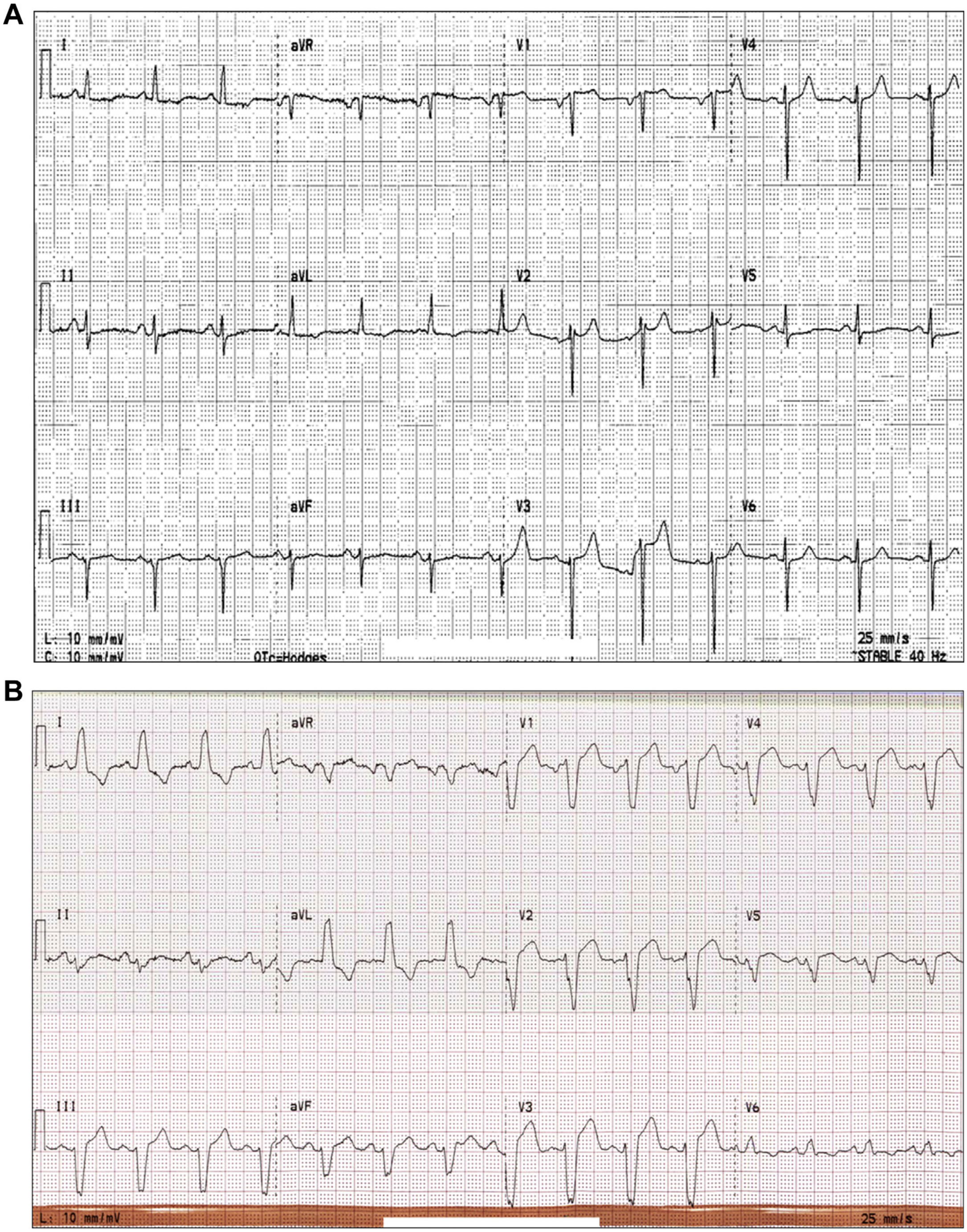

Figure 1 **A:** A 12-lead electrocardiogram prior to septal myectomy showing sinus rhythm, left atrial enlargement, and left axis deviation with a QRS duration of 88 ms. **B:** A 12-lead electrocardiogram soon after septal myectomy demonstrating normal sinus rhythm, new left bundle branch block, and a QRS duration of 160 ms.

Discussion

SICDs are effective in detecting and treating life-threatening ventricular arrhythmias.[1] SICD implantation avoids complications associated with intravascular lead placement, and can be used in eligible patients without pacing indications. Adequate ECG screening is important prior to implantation. The QRS-T wave morphology is used to identify if a patient is a candidate for an SICD and surface ECG is used as a substitute of subcutaneous ECG.[2] The SICD implant configuration allows 3 different vectors to sense: primary, secondary, and alternate. These vectors are screened using variations of ECG leads; positioning right arm lead in left sternal border at second costochondral joint, left arm lead in left sternal border at level of sixth costochondral joint, and finally positioning left leg lead in left anterior axillary line at level of sixth rib.[3] Patients are considered suitable if 1 or 2 sensing vectors are considered appropriate. Screening is successful in the majority of patients being evaluated for SICD. In a study performed on 96 patients

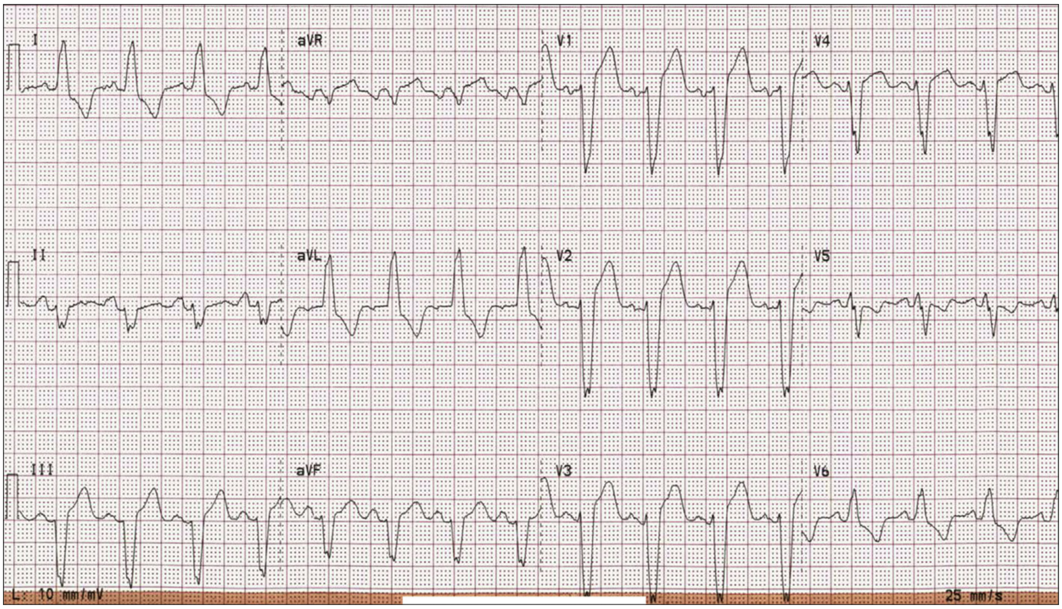

Figure 2 A 12-lead electrocardiogram (ECG) 39 days after septal myectomy showing sinus rhythm with left bundle branch block and a QRS duration of 154 ms. Notice the taller T waves compared to the ECG done shortly after myectomy.

with indication for an ICD, the SICD screening template demonstrated that 85.2% of the patients had a surface ECG suitable for eligibility, which required 2 or more leads to satisfy the SICD screening. If only 1 lead was required to be eligible, this percentage increased to 96.4%.[4] Independent risk factors that increased the chance of screening failure included HCM (odds ratio [OR] 12.6), obesity (OR 1.5), prolonged QRS duration (OR 1.5), R/T wave ratio < 3 in the lead with the largest T wave on a standard 12-lead ECG (OR 14.6),[5] and T-wave inversions in inferior leads.[6]

In patients with HCM, SICDs have proven to be effective despite extreme left ventricular hypertrophy.[7] These patients may, however, have higher screening failure. In a study done in 131 patients with HCM, 38% of patients were found to have screening failure in every lead vector. Higher R/T wave ratio in the screening ECG was associated with screening failure (OR 4.0; confidence interval [CI] 3.0–5.3; $P < .001$). Variables associated with lower screening failure were R/T ratio < 3 in aVF (OR 0.3; CI 0.12–0.69; $P = .006$) and increased age (OR 0.97; CI 0.95–0.99; $P = .03$).[8] Exercise screening has been used to help screen patients with HCM and severe hypertrophy, but studies have shown mixed results.[3,9,10]

Similar to patients that have a transvenous ICD, patients with SICD may experience inappropriate discharges. In a prospective observational study of 581 patients with SICDs, 8.3% of patients received an inappropriate shock. These were caused by cardiac signal oversensing in 5.7% of patients,

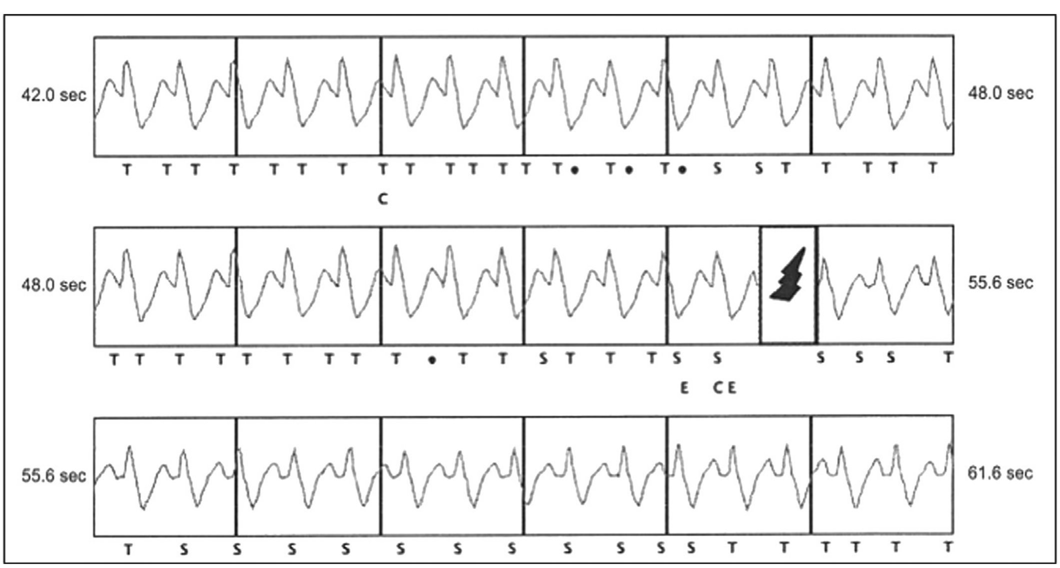

Figure 3 Subcutaneous implantable cardioverter-defibrillator interrogation strip showing sinus tachycardia and inappropriate shock from T-wave oversensing.

followed by supraventricular tachycardia in 2.1% of patients. HCM and atrial fibrillation were independent predictors of inappropriate shocks.[11]

New algorithms for SICDs have been developed that decrease TWOS in up to 30%–40% (SMARTPASS filter). This complex algorithm analyzes the 3 sensing vectors and selects the one with a lower risk of oversensing. Once this is achieved, it integrates a comparison between the template and the complex in question, compares the complex in question with the 3 last complexes, and finally also compares its QRS width.[12] This algorithm was developed with a database of recorded episodes and should translate adequately to patients with HCM.

Septal reduction surgery with either septal alcohol ablation or septal myectomy is indicated in patients with HCM refractory to medical treatment in order to relieve outflow obstruction. After these procedures, new conduction system defects may develop in up to 84.3% of cases. These include LBBB, interventricular conduction delay, left anterior hemi-block, left axis deviation, and complete heart block. LBBB can develop in up to 30% of patients undergoing septal myectomy[13] and alcohol septal ablation carries a higher risk of pacemaker implantation (10% compared to 4.4% after myectomy, $P < .001$).[14]

Our patient, following myectomy, developed a new LBBB, causing his T-wave vector to change. Unfortunately, in our patient's case, following surgery, no changes were made to the sensing vector (primary). Our case shows that following development of a new bundle branch block or interventricular conduction delay after myectomy/septal reduction, it is important that the SICD be immediately reinterrogated and templates updated to rule out oversensing.

Interestingly, the patient maintained appropriate sensing in the primary vector for 3 months post-surgery before TWOS occurred. It appears, from serial ECGs, that these repolarization changes were dynamic and continued to evolve over a period of 3 months and likely served as a substrate for TWOS. Thus, close monitoring of SICD sensor settings immediately after surgery and up to several months after surgical therapy might be required for patients with HCM in order to detect TWOS and avoid inappropriate shocks. A prior case of inappropriate shock from an SICD in a patient with HCM, 2 days after alcohol septal ablation and associated with development of a new right bundle branch block and TWOS, has been reported by Van Dijk and colleagues.[15] To our knowledge, this is the first reported case of an inappropriate SICD shock caused by new LBBB and delayed repolarization abnormalities causing TWOS in an HCM patient following septal myectomy.

Another question that is pertinent is whether or not it is viable to continue SICD in the presence of new conduction abnormalities following myectomy. An added concern will be the sensing behavior in the presence of significant sinus tachycardia, as the patient was tachycardic at the time TWOS occurred. We certainly debated this quite a bit and had a detailed discussion with the patient. We were able to get good sensing without any TWOS at rest and with activity with alternate vector and SMARTPASS turned on. The switch to alternate vector also changed also changed the QRS axis compared to the T wave (Supplemental Figure A–C). We also increased the beta blocker dosing. After a lengthy discussion with the patient, it was mutually decided to continue with SICD. However, we are cognizant that a potential risk of TWOS still exists; we remain watchful and continue to closely monitor the patient. Clearly, further studies are needed to assess long-term risk of TWOS in this scenario.

Appendix

Supplementary data

Supplementary data associated with this article can be found in the online version at https://doi.org/10.1016/j.hrcr.2018.06.004.

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