A case of frequent and inappropriate shock with a subcutaneous implantable cardioverter-defibrillator triggered by newly developed complete right bundle branch block

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Introduction

An implantable cardioverter defibrillator (ICD) can reduce the risk of sudden cardiac death due to ventricular arrhythmia.[1,2] However, long-term complication risk, such as lead dysfunction, remains a major limitation.[3] Addition of transvenous leads alone carries a venous stenosis or occlusion risk, and removing leads carries a venous injury risk.[4] Therefore, the indications for ICD implantation should be judged carefully, especially in young patients.

The subcutaneous ICD (S-ICD) was introduced to avoid these lead complications. An S-ICD is implanted subcutaneously and does not course through the veins, allowing for vein preservation. Patients who are going to be implanted with an S-ICD need to pass a screening electrocardiogram (ECG) test; however, some of them fail to pass this test.

We present a case report of frequent inappropriate shocks with an S-ICD triggered by newly developed complete right bundle branch block (CRBBB) despite the patient's passing the ECG screening test recorded at the skin before S-ICD implantation.

KEY TEACHING POINTS

- Complete right bundle branch block (CRBBB) is a common electrocardiogram (ECG) change. However, CRBBB is known to be the risk factor for a failed screening or for sensing disturbances after implantation, but not for indication of subcutaneous implantable cardioverter-defibrillator (S-ICD).
- The morphological QRS changes in the standard 12-lead ECG can be the initial clue that the patients with S-ICD become ineligible for this device after S-ICD implantation. We should carefully follow up ECG change in patients with S-ICD.
- The S-ICD is often selected to preserve patients' veins, especially in young patients. However, once the ECG changes, inappropriate shocks may be uncontrollable.

Case report

A 59-year-old man visited our hospital because the S-ICD frequently began delivering shocks while the patient was conscious. Four years ago, the patient was implanted with an S-ICD with a diagnosis of idiopathic ventricular fibrillation. The patient had a history of hypertension and was taking nifedipine 20 mg/day and bisoprolol 2.5 mg/day.

His 12-lead ECG at S-ICD implantation showed mild ST elevation with J waves in the II, III, and aVF leads as well as clockwise rotation of QRS transitional zone (Figure 1A). In the screening ECGs recorded at the skin, the primary and secondary vectors were ineligible, and only the alternate vector was eligible in all positions, such as lying down, seated, and lying on the right side (Figure 2A). Therefore, the patient was indicated for an S-ICD. The S-ICD was implanted in the left margin of the sternum, and the shock was confirmed to be delivered appropriately. Although the primary vector was ineligible on screening ECGs at the skin, it became eligible after S-ICD implantation, so the device was configured to use the primary vector. The S-ICD was programmed with a conditional zone over 200 beats per minute, a shock zone over 220 beats per minute, and gain settings 1×. Treadmill

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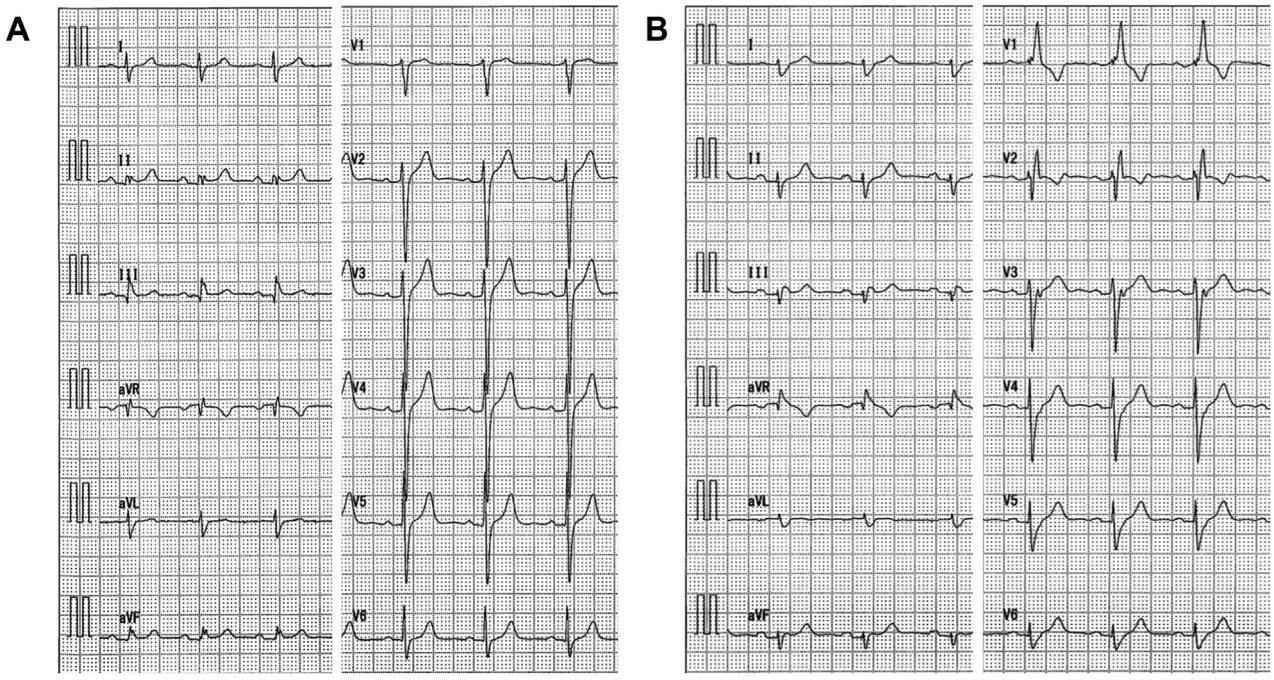

Figure 1 Twelve-lead electrocardiogram (ECG) finding comparison. **A:** ECG at subcutaneous implantable cardioverter defibrillator (S-ICD) implantation showed mild ST elevation with J waves in the II, III, and aVF leads and showed clockwise rotation of QRS transitional zone. **B:** ECG after frequent shocks of the S-ICD showed newly developed complete right bundle branch block and an indeterminate axis. In the I, II, and aVF leads, QRS-T discordance was observed.

exercise testing was performed, and all vectors were screened during exercise. When his heart rate increased during treadmill exercise testing, T-wave oversensing did not occur. After implantation, the S-ICD did not deliver any inappropriate shock.

However, after 4 years, the S-ICD began frequently delivering shocks while the patient was conscious. The 12-lead ECG showed newly developed intermittent CRBBB, indeterminate axis, and QRS-T discordance in I, II, and aVF leads (QRS-T discordance is defined as oppositely oriented vectors of QRS and T wave[5]) (Figure 1B). Chest radiograph showed no obvious S-ICD lead displacement. His weight had not increased or decreased markedly in 4 years. Figure 3 shows the detected ECG with the S-ICD in the primary vector. T-wave oversensing caused the inappropriate shocks. Figure 3 also shows the temporary normal QRS count in the bottom line when the ECG changed to normal conduction from CRBBB. After frequent shocks of the S-ICD, the screening ECGs recorded at the skin became ineligible in all vectors (Figure 2B). And the screening ECGs on the right margin of the sternum showed ineligibility. We followed his 12-lead ECG once in 6 months for 4 years after

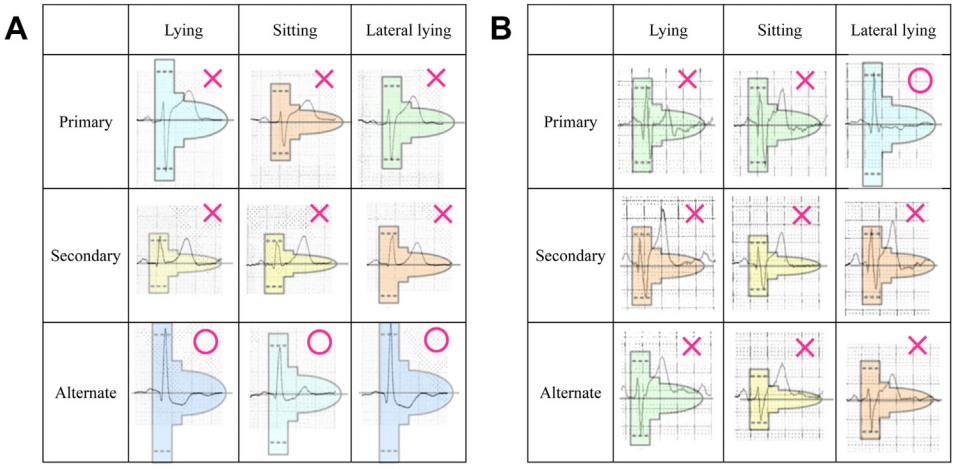

Figure 2 Screening electrocardiograms (ECGs) were recorded at the skin. (I) primary vector, (II) secondary vector, and (III) alternate vector. **A:** ECG at subcutaneous implantable cardioverter defibrillator (S-ICD) implantation. The primary and secondary vectors were ineligible and only the alternate vector was eligible for all positions, including lying down, seated, and lying on the right side. **B:** ECG after frequent shocks of the S-ICD. All vectors became ineligible.

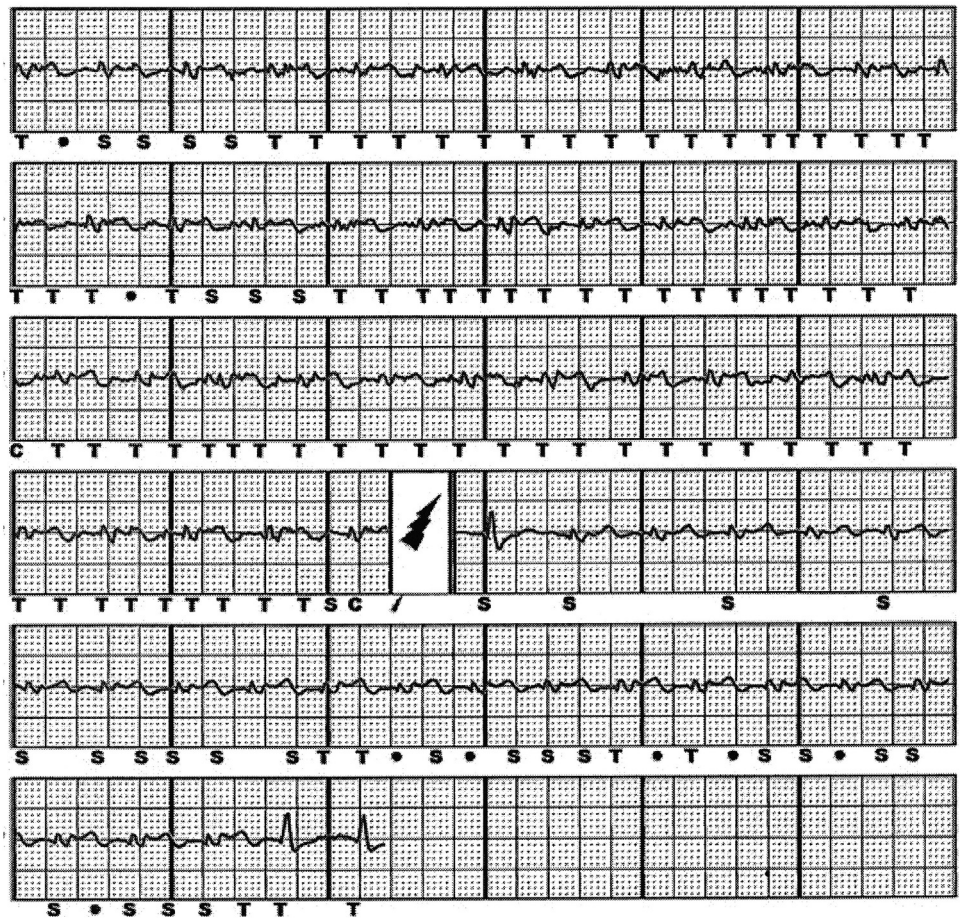

Figure 3 Electrocardiogram (ECG) detected by the subcutaneous implantable cardioverter defibrillator (S-ICD) in the primary vector. QRS and T wave were doubly counted, which caused inappropriate shocks. The final 2 QRS waves showed the temporary normal QRS count in the bottom line when ECG changed normal conduction from complete right bundle branch block.

S-ICD implantation. CRBBB did not show before frequent inappropriate shock, but it was observed after frequent inappropriate shock and was considered as the cause of these shocks.

The β-blocker administration was temporarily stopped, but CRBBB did not improve. In addition, CRBBB was sustained from intermittent. Bisoprolol was increased from 2.5 to 5 mg/day to reduce his heart rate, and the sensing vector was changed from the primary to the alternate. However, the S-ICD still inappropriately delivered shock, so it was removed and a transvenous ICD (TV-ICD) was implanted. Since its implantation, the TV-ICD has not delivered any inappropriate shock.

Discussion

According to the EFFORTLESS study, inappropriate shocks of the S-ICD occurred in 8.1% at 1 year and 11.7% at 3 years, with T-wave oversensing or low-amplitude signals (63%) being the main cause.[6] The S-ICD was proven noninferior to a TV-ICD with respect to device-related complications and inappropriate shocks in patients with an ICD indication but no indication for pacing.[7]

There have been a few case reports of frequent inappropriate shocks with an S-ICD triggered by newly developed bundle branch block. Kempa and colleagues[8] reported that although the S-ICD did not deliver inappropriate shocks, it detected T-wave oversensing during transient bundle branch block. Sousa and Betts[9] reported a case of inappropriate shocks from an S-ICD owing to T-wave oversensing by rate-related CRBBB. The case showed that T-wave oversensing during exercise was resolved by reprogramming the sensing vector to be unaffected by the rate-dependent CRBBB.[9] According to both cases, a bundle branch block can cause T-wave oversensing in S-ICD sensing vector. By the same token, this case of frequent and inappropriate shocks with S-ICD was caused by T-wave oversensing by newly developed CRBBB. T-wave oversensing occurred not only during exercise but also during resting state; therefore, this problem could not be resolved by reprogramming.

A previous case reported that lead repositioning could be helpful for preventing inappropriate shocks.[10] However, the screening ECGs on the right margin of the sternum also showed ineligibility. Thus, lead repositioning was considered unhelpful for preventing inappropriate shocks in this case. A

dynamic change of the generator position has a risk of high defibrillation threshold.[11] In light of the above, the inappropriate shocks with the S-ICD were considered uncontrollable, so it was replaced with a TV-ICD.

From a previous report, 19% of potential patients for S-ICD were considered unsuitable for S-ICD when evaluated with a surface ECG screening template, and CRBBB and QRS-T discordance in the I, II, and aVF leads with a standard 12-lead ECG are known to be independent predictors for a failed S-ICD indication.[5] QRS-T discordance was defined as oppositely oriented vectors of QRS and T-wave vectors.[5] In this case, his 12-lead ECG showed CRBBB and QRS-T discordance in the I, II, and aVF leads.

CRBBB alone does not change the general axial deviation, but in this case the indeterminate axis also changed from a normal axis after newly developed CRBBB. Annual echocardiography was normal for 4 years after S-ICD implantation, and his weight had not changed markedly. The cause of the axial deviation was unclear.

Some doctors may think it is a mistake to implant an S-ICD in cases where only 1 vector is eligible in the screening ECG test. However, it was reported that, compared to preoperative vectors as assessed by S-ICD screening ECG, the number of eligible vectors may actually increase after S-ICD implantation.[12] The reason for this difference is because screening ECGs are recorded at the skin, whereas the ECGs detected by the S-ICD are recorded under the skin.[12] In addition, in this case, the eligible vectors increased from 1 vector (alternate) to 2 vectors (primary and alternate) after S-ICD implantation. Thus, we were able to preserve this young patient's veins for 4 years, and if CRBBB had not developed, these might have been preserved longer. It is therefore believed that an S-ICD indication should be considered aggressively, especially in young patients, even if only 1 vector is eligible in the screening ECGs test.

It is reported that, during follow-up after S-ICD implantation, the morphological changes in QRS in the standard 12-lead ECG can be the initial clue that the patients with S-ICD become ineligible for this device.[5] We should carefully follow up ECG change in patients with S-ICD.

In summary, we reported a case of frequent inappropriate shocks with an S-ICD triggered by newly developed CRBBB. Inappropriate shocks with the S-ICD were uncontrollable in this case at all. CRBBB is common branch block, and a bundle branch block might be the cause of T-wave oversensing with an S-ICD. Thus, we should carefully follow up ECG change in patients with S-ICD.

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