Inappropriate detection of an intraventricular conduction delay as a lead failure due to an increase in the sensing integrity counter in a patient with a cardiac resynchronization therapy-defibrillator

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Introduction

Lead failures are one of the major complications of implantable cardioverter-defibrillator (ICD) therapy, often leading to a series of inadequate shocks and thus greatly impairing the quality of life in patients and causing potential proarrhythmias.[1] The sensing integrity counter (SIC), which is an algorithm that detects the cumulative count of very short ventricular sensed intervals, may enhance the early detection of lead failures.[2–4] Here we present a rare case in which a prolonged QRS duration caused an inappropriate SIC increase and mimicked a lead failure.

Case report

A 58-year-old woman underwent an implantation of a cardiac resynchronization therapy-defibrillator (CRT-D) (Medtronic Protecta XT; Medtronic Inc, Minneapolis, MN) for a dilated phase of hypertrophic cardiomyopathy with a 34% left ventricular ejection fraction and secondary prevention for ventricular arrhythmias 3 years prior. A Sprint Quattro dual-coil lead (Medtronic Inc, Minneapolis, MN) was used as the ICD lead and the R-wave amplitude was 6.2 mV at the time of the CRT-D implant. Her paroxysmal atrial tachycardia (AT) was refractory to some antiarrhythmic drugs and multiple radiofrequency catheter ablation applications. Amiodarone could not be used owing to drug-induced interstitial pneumonia. A dose of 2.5 mg of bisoprolol and 160 mg of sotalol were used to manage her heart failure and AT; however, she was intolerant to a further increased dose owing to her cardiac function with a left ventricular ejection fraction of 22%. An atrioventricular node ablation with biventricular pacing was also considered at the time of the CRT-D implant. Biventricular pacing at 70 to 80 beats per minute to simulate the situation after the atrioventricular node ablation was performed once during her AT; however, her blood pressure declined and she became intolerant to VVI pacing. The initial setting of the CRT-D was DDI mode at the time of the device implant. The cumulative percentage of biventricular pacing had increased up to 11% during the follow-up and the most recent pacing mode was set to AAI

KEY TEACHING POINTS

- Lead failures are one potential cause of inappropriate implantable cardioverter-defibrillator (ICD) therapy. Inappropriate ICD therapy may cause pain, psychological distress, and potentially fatal proarrhythmias.
- The sensing integrity counter (SIC), which is an algorithm that detects the cumulative count of very short ventricular sensed intervals, may enhance the early detection of lead failures. A SIC count >300 identified ICD lead failures with a 92.9% sensitivity, 97.1% specificity, and positive predictive value of 59.1%.
- A few cases with an inappropriate SIC increase have been reported, which were caused by misunderstanding of the T waves, short coupled premature ventricular contractions with a short interval of the ventricular sensing, and intermittent far-field oversensing of cardiac or diaphragmatic potentials for the integrated bipolar sensing. However, it was rare that an intraventricular conduction delay due to a sodium channel blockade caused the inappropriate SIC increase.

KEYWORDS Atrial tachycardia; Cibenzoline; Implantable cardioverter-defibrillator; Lead failure; Lead integrity alert; Sensing integrity counter

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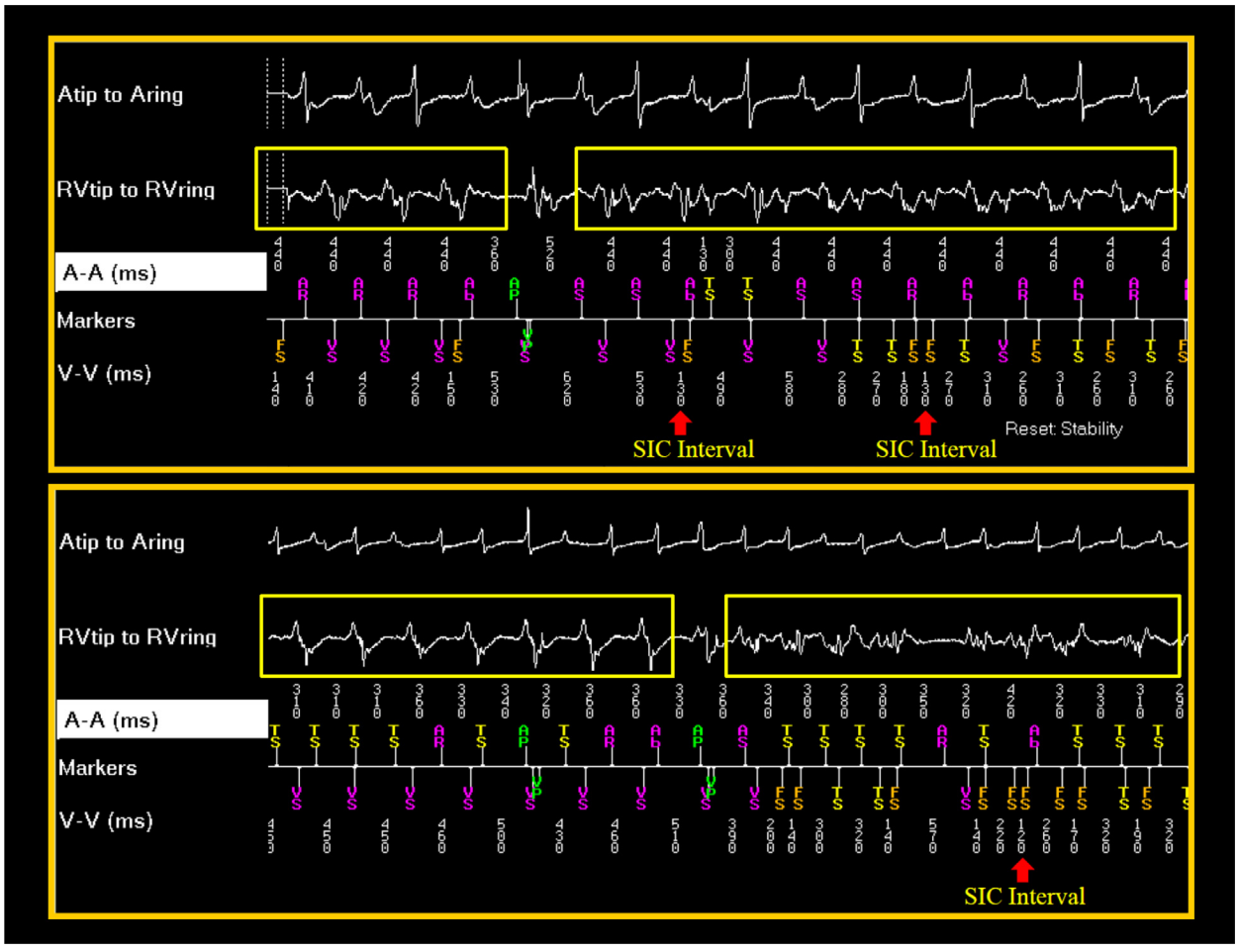

Figure 1 Intracardiac electrocardiogram showing an increase in the sensing integrity counter caused by QRS prolongation.

at 80 beats per minute at a lower rate to preserve her intrinsic AV conduction.

She entered another hospital for symptomatic AT, and the AT was successfully terminated after an intravenous administration of cibenzoline. On the next day, we had a call about a CRT-D alarm. Upon device interrogation, the CRT-D alarm was caused by a lead integrity alert (LIA). In detail, the SIC, which cumulatively counts short V-V intervals (<140 ms) and thereby typically indicates intermittent oversensing of electrical noise, had increased and lots of nonsustained ventricular tachycardia (NSVT) events were recorded. Although the total number of the SIC was 883 since the CRT-D implantation, the SIC had increased by 859 counts with a span of 6 days. Owing to that increase in the SIC, we suspected an ICD lead failure and oversensing of lead noise; however, the ICD lead impedance and pacing threshold had almost no change (the ICD lead impedance was 304 Ω, right ventricular [RV] coil impedance 47 Ω, superior vena cava coil impedance 60 Ω, RV capture threshold 0.875 V at 0.4 ms, and R-wave amplitude 4.1 mV). We analyzed the intracardiac electrocardiogram (iEGM) recordings during the increase in the SIC count (Figure 1). According to the iEGM, the increase in the SIC was recorded during the AT and an intravenous administration of cibenzoline was administered (Figure 2A). Two minutes after the intravenous administration of 70 mg of cibenzoline, the AT was sustained while the QRS duration increased to 280 ms (Figure 2B). Twenty minutes later, the AT terminated and transitioned to atrial pacing with intrinsic ventricular conduction; however, the QRS prolongation was sustained (Figure 2C). Thirty minutes later, the QRS prolongation gradually shortened (Figure 2D) and the QRS duration returned to 120 ms 4 hours later, which was the same as her normal duration (Figure 2E). We analyzed the iEGM more closely during the QRS prolongation. The iEGM from the ICD lead exhibited QRS-wave prolongation and fragmentation during the same AT, which had the same tachycardia cycle length. The fragmentation was recorded only after the cibenzoline administration. Multiple RV sensing components were recorded in a single QRS complex and were misunderstood as a short R-R interval (<140 ms) (Figure 3). Similarly, oversensing of the QRS fragmentation as a short R-R interval, which was longer than 140 ms, was misunderstood as an NSVT. Thereafter, both the increase in the SIC count and several short NSVT episodes led to an LIA. After the improvement in the QRS prolongation, the SIC count no longer increased, so we ultimately did not change any settings and the same event no longer occurred after those episodes.

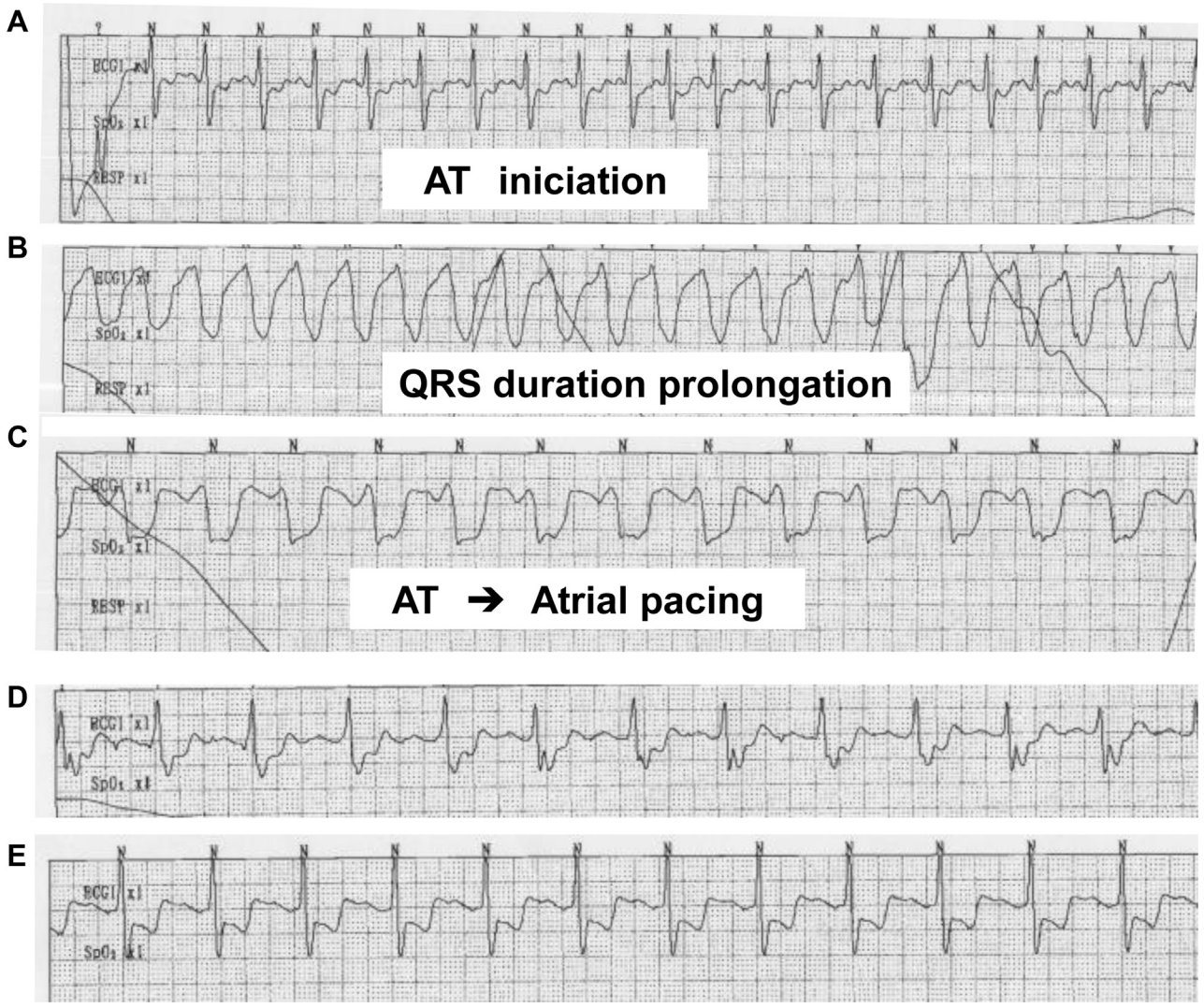

Figure 2 Changes in the QRS morphology. **A:** Initiation of atrial tachycardia (AT). **B:** Two minutes after administration of cibenzoline. **C:** Twenty minutes later, the AT terminated. **D:** Thirty minutes later. **E:** Four hours later.

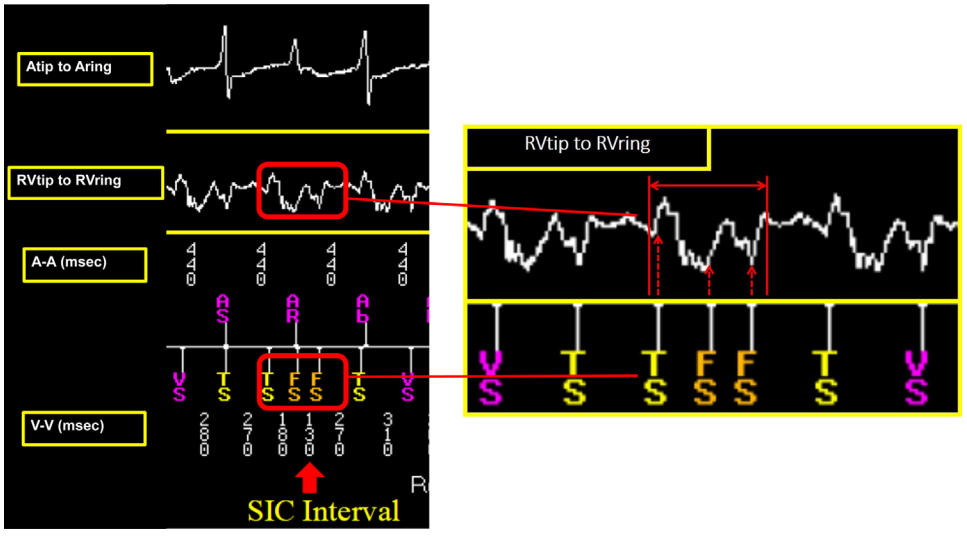

Figure 3 Multiple sensing components during a single QRS complex in intracardiac electrocardiogram. SIC = sensing integrity counter.

Discussion

Despite the benefits of ICDs in preventing sudden cardiac death, device failures due to ICD lead problems remain a challenging problem for the ICD recipients.[5,6] Lead failures are 1 potential cause of inappropriate ICD therapy. An insulation defect or conductor fracture within the pace-sense circuit can produce electrical noise, and oversensing of these high-frequency signals can result in inappropriate detection of ventricular arrhythmias and unnecessary ICD therapy. Inappropriate ICD therapy may cause pain, psychological distress, and potentially fatal proarrhythmias.[1] The SIC can detect these brief episodes of noise oversensing and may thereby enhance the early detection of lead failures with a high statistical accuracy. A SIC count >300 identified ICD lead failures with a 92.9% sensitivity, 97.1% specificity, and positive predictive value of 59.1%.[3] Moreover, the development of the LIA algorithm was a response to the premature Sprint Fidelis (Medtronic Protecta XT) lead failures. The LIA was triggered in the presence of ≥2 of the following circumstances: an abrupt change in the pacing or shocking lead impedance, frequent SIC increase, or ≥2 ICD-defined episodes of rapid NSVT. The advantage of the LIA algorithm was a superior sensitivity and specificity compared to conventional algorithms based on the conventional electrical parameters such as the lead impedance and capture threshold.[7–9] Although a few cases with an inappropriate SIC increase have been reported, which were caused by misunderstanding of the T waves, short coupled premature ventricular contractions with a short interval of the ventricular sensing, and intermittent far-field oversensing of cardiac or diaphragmatic potentials for the integrated bipolar sensing,[10,11] it was rare that an intraventricular conduction delay due to a sodium channel blockade caused the inappropriate SIC increase.

ICD leads have an "autogain" sensing algorithm, which adjusts the sensing thresholds dynamically to ensure reliable sensing of low and varying-amplitude electrograms during ventricular fibrillation. However, this algorithm can sometimes cause oversensing with a sharper sensitivity, such as with T-wave oversensing. In this case, the R-wave amplitude decreased compared to that at the time of the CRT-D implant (6.2 mV to 4.1 mV). This decrease in the R-wave amplitude might have occurred owing to the progression of worsening chronic heart failure based on progressive hypertrophic cardiomyopathy. Moreover, the R-wave amplitude became lower, to 2.5 mV during the AT. The ICD lead sensitivity should result in sharper signals with the autogain algorithm. On the other hand, the QRS duration had prolonged and multiple notches appeared in 1 QRS complex. Therefore, the ICD lead might be able to detect the notches as small-amplitude R waves with short intervals. Further, the detection of R-R intervals <140 ms resulted in the SIC increase and R-R intervals ≥140 ms among the VT setting zone was detected as a VT episode. Fortunately, all the recordings of the VT episodes were observed as short NSVTs and ICD therapies for those VT episodes were not committed. Both the increase in the SIC and frequent NSVT episodes resulted in the LIA and CRT-D alarm.

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