Recurrent implantable cardioverter-defibrillator shocks due to automatic deactivation of a right ventricular lead noise discrimination algorithm

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Introduction

In patients at risk of fatal ventricular arrhythmias, an implantable cardioverter-defibrillator (ICD) effectively reduces mortality.[1,2] However, inappropriate shock deliveries depict a major limitation of ICDs and are mainly induced by erroneous discrimination of supraventricular tachycardias or oversensing of P, R, or T waves; myopotentials; electromagnetic interference; or noise signals of defective leads.[3]

The Abbott SecureSense (Abbott Medical, St. Paul, Minnesota) right ventricular (RV) lead noise discrimination algorithm has previously been proven to efficiently reduce inadequate shocks in patients with RV lead noise.[4–6] Based on a continuous comparison between a near-field channel (derived from RV tip-to-ring or tip-to-coil signal) and a far-field channel (derived from RV tip-to-can or coil-to-can signal), RV noise signals are reliably detected in case of discrepant near-field and far-field signals and consequently, inappropriate shock delivery can be withhold (further information is displayed in Figure 1).[6]

In the following case presentation, we report about repetitive inappropriate ICD shocks due to an automatic switch into passive mode of the SecureSense algorithm during device interrogation.

KEY TEACHING POINTS

- The Abbott SecureSense (Abbott Medical, St. Paul, Minnesota) algorithm adequately detects right ventricular noise signals by comparing near-field and far-field signals and reduces inappropriate implantable cardioverter-defibrillator (ICD) shocks evoked by oversensing.
- By default, appliance of the telemetry wand automatically induces passive mode of the SecureSense algorithm. As a consequence, right ventricular noise signals are still appropriately detected during device interrogation, but ICD therapy is not withheld, which may allow inappropriate ICD shocks in case of simultaneous or ongoing right ventricular noise.
- To avoid inappropriate ICD shocks, we therefore suggest to perform device interrogation with parallel magnet application in any case of suspected (in)adequate shock delivery.

Case report

A 46-year-old woman with a history of sudden cardiac death due to idiopathic ventricular fibrillation presented to our emergency department owing to recurrent ICD shocks. Prior medical history is summarized in Table 1.

At admission, our patient reported repetitive ICD shocks while brushing her teeth and climbing stairs. A previously noticed vibration alert of the ICD was deliberately ignored by the patient. She denied palpitations, dizziness, or syncope; also, we had no anamnestic evidence for ongoing ischemia or decompensated heart failure.

The physical examination was normal and a routine blood sample revealed slightly elevated troponin levels, which was explained by the recent ICD shocks. A 12-lead electrocardiogram (ECG) showed sinus rhythm and the chest radiograph (Figure 2) displayed no evidence for lead fracture, dislocation, or insulation defects.

KEYWORDS ICD; SecureSense algorithm; Inappropriate shocks; Safety; Lead failure

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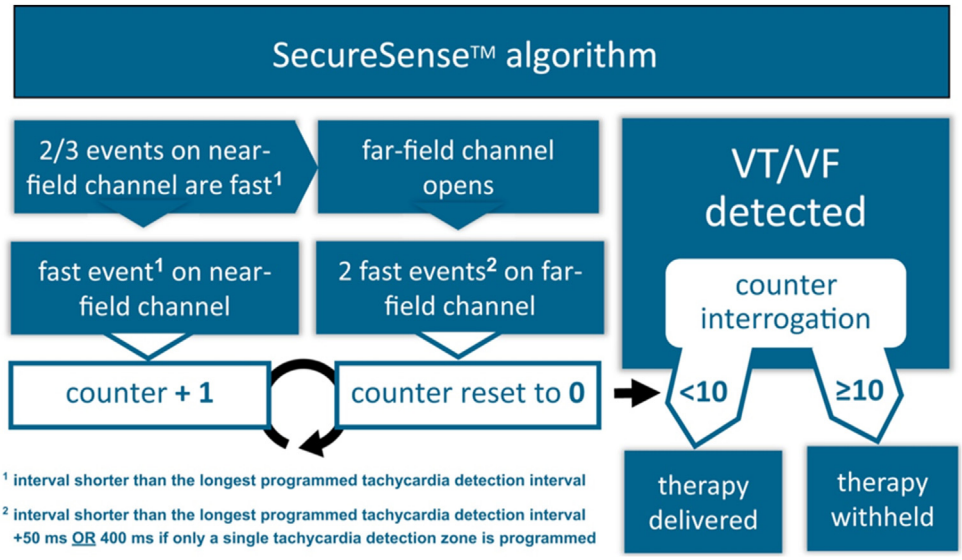

Figure 1 Continuous surveillance and detection of discrepant signals in the near-field (NF) and far-field (FF) channel allow to differentiate oversensing from real ventricular arrhythmias. Every fast interval on the NF channel is counted in increments, while the counter is reset to zero, when 2 fast intervals are detected on the FF channel. A true ventricular tachycardia (VT) should therefore constantly reset the counter because of fast intervals on the FF channel. Implantable cardioverter-defibrillator therapy is withheld, when the counter is ≥10, while VT is detected. The fast intervals are defined by the programmed VT zones. In case of suspected undersensing (>2 sensed events with amplitude <0.6 mV; <2 sensed events, intervals longer than 2200 ms) and during device interrogation the SecureSense (Abbott Medical, St. Paul, Minnesota) algorithm is (by default) automatically switched to passive mode, where therapy inhibition is disabled. The active mode is automatically reactivated as soon as the device interrogation has been finished properly. Caution is required in case of incompletely finished sessions, where the algorithm is reactivated only after 30 minutes. Further details are published elsewhere.[6]

At the beginning of the subsequent ICD interrogation, a total of 4 shocks were delivered after placement of the telemetry wand, while a parallel real-time 12-lead ECG showed sinus rhythm. Immediately, a magnet was placed to deactivate the device. A second ICD interrogation was further performed under sedation (owing to panic) and with magnet application, to ensure continuous therapy inhibition.

The device report confirmed recurrent noise signals of the RV lead (Figure 3), which were adequately detected by the SecureSense algorithm. RV lead and shock impedance (463 ohms and 64 ohms, respectively), sensing amplitude (12.6 mV), and pacing threshold (1.1 V / 0.4 ms) were stable compared to previous controls. However, as inappropriate ICD shocks were again repetitively delivered during the first device interrogation, troubleshooting was carried out by the manufacturer. This revealed that the SecureSense algorithm automatically switches into passive mode by default during device interrogation. Therefore, even though RV noise was appropriately detected, therapy suppression no longer took place, which led to shock delivery (Figure 3).

Unfortunately, the intracardiac ECG of the first ICD shocks perceived by our patient were not stored, as the device only has capacity to register the latest 60 episodes.

Table 1 Timeline of medical history

02/2007	ICD implantation due to idiopathic ventricular fibrillation *Device: Biotronik Lumax 340 HF-T* *Atrial lead: St. Jude 1388T Tendril SDX, SN GW28169* *Ventricular lead: Biotronik Linox SD 65/16*
08/2009	RV lead extraction and reimplantation owing to lead fracture *New RV lead: Biotronik Linox SD 65/16, SN 10335312*
06/2012	Elective ICD box change due to low battery *Device: St. Jude Ellipse DR*
06/2014	ICD box change due to malfunction (capacitor maintenance charging time out) *Device: St. Jude Ellipse DR CD 2377-36C, SN* 1083287
03/2022	Recurrent inadequate ICD shocks

ICD = implantable cardioverter-defibrillator; RV= right ventricular.

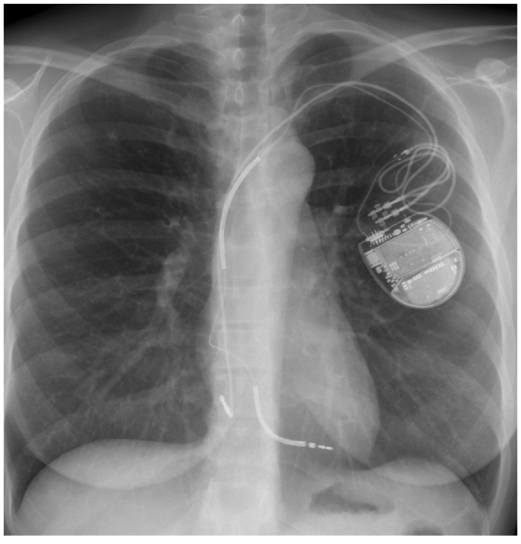

Figure 2 Chest radiograph shows left pectoral device location with adequate positioning of the atrial lead in an anterolateral position and of the ventricular lead in an apical-septal position. There is no evidence of lead fracture or insulation defects.

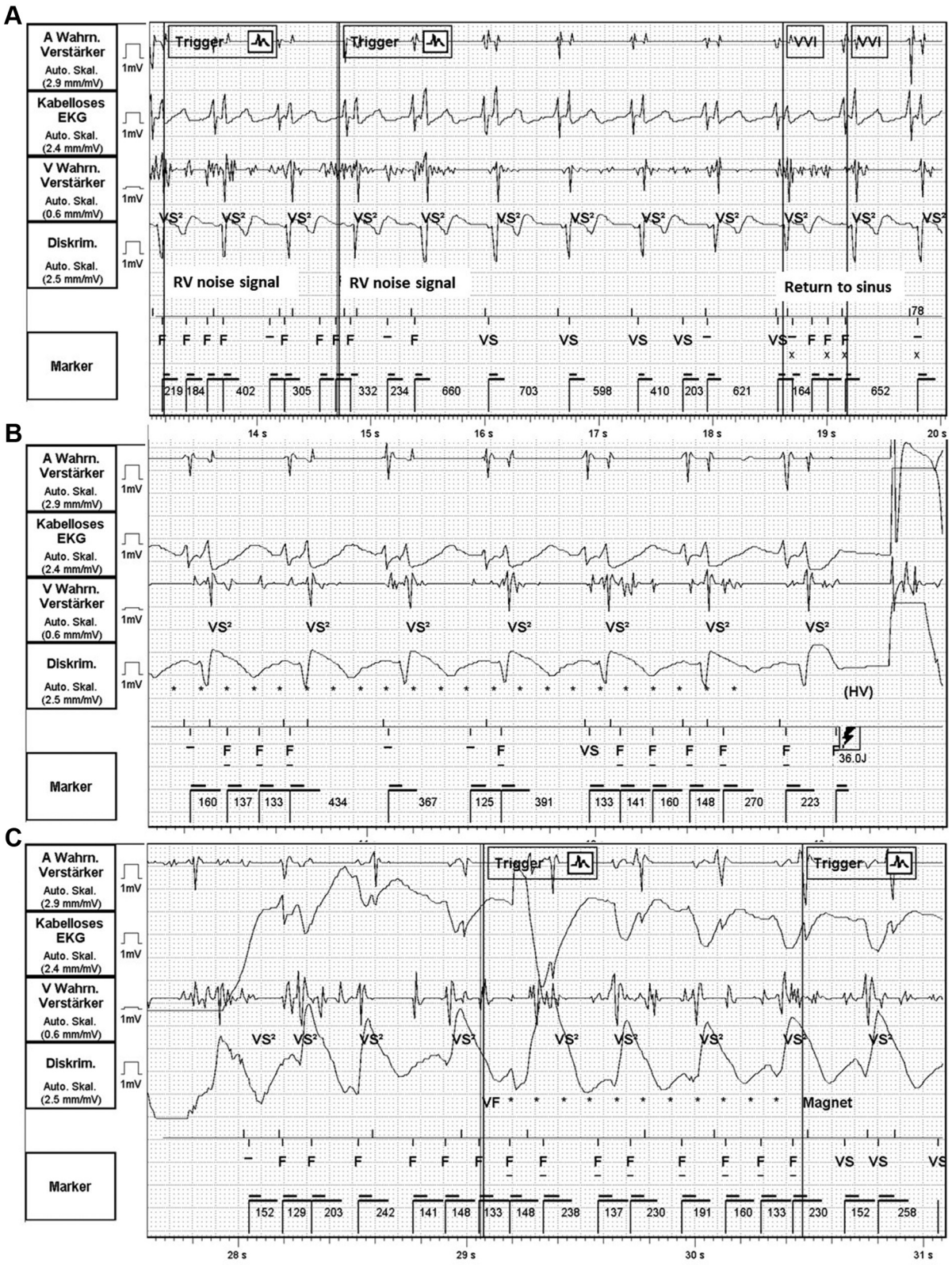

Figure 3 **A:** Right ventricular (RV) lead noise is appropriately detected and therapy inhibited by the SecureSense (Abbott Medical, St. Paul, Minnesota) algorithm (marked as "RV Lead Noise"). **B:** Illustratively depicted are the appropriately detected RV noise signals. Owing to induction of passive mode of the SecureSense algorithm during device interrogation, shock delivery is not inhibited by the algorithm and inappropriately delivered with 36 joules. **C:** Immediately a magnet was placed to inhibit antitachycardic therapy of the implantable cardioverter-defibrillator. Near-field electrocardiogram (ECG) is derived from RV tip-to-coil signal and the far-field channel is derived from RV tip-to-can signal.

As our patient never required adequate therapies during her entire time as an ICD carrier and never had documented ventricular arrhythmias in the device memory, we temporarily deactivated the ICD. Because of enormous psychological stress and extreme fear of recurrent episodes, she wished to explant the ICD unit, whereas the old leads were disconnected and not explanted because of increased periprocedural risk for lead extraction. The patient is currently well and under cardiopsychological care.

Discussion

To the best of our knowledge, we are the first to describe safety issues with the by-default programmed, automatic deactivation of the SecureSense algorithm induced by ICD device interrogation. Although preliminary reports confirmed reliable suppression of inadequate ICD shocks in the setting of RV noise by the SecureSense algorithm,[4–6] this malfunction is a potentially dangerous device behavior, and an efficient strategy needs to be elaborated to avoid future events.

Importantly, mortality is negatively affected by both inadequate and adequate ICD shock deliveries.[7,8] It is therefore crucial not only to prevent any ventricular arrhythmia with medical therapy or ablation therapy, but also to reduce risk for inadequate shock deliveries. Additionally, the psychological stress resulting from (inadequate) shock deliveries is often very burdensome and may even evoke chronic anxiety.[9]

Besides misinterpretation of supraventricular tachycardias, oversensing, artefacts, or noise may provoke up to 13% of inadequate shock deliveries[10]—for this purpose the SecureSense algorithm was shown to be effective. Moreover, a generous surveillance with remote monitoring systems may prematurely identify patients at risk for inadequate shock deliveries (eg, detection of RV noise signals or artefacts) and allow early interventions, such as alternative device programming or lead revision. In the case of our patient, remote monitoring would have revealed RV noise at an early stage and inappropriate shocks could have been avoided with premature lead revision. This early surveillance strategy should be particularly considered in patients with implanted leads known to be prone to lead fractures, such as the Biotronik Linox SD lead in our patient.[11,12]

The presenting case revealed that the SecureSense algorithm is intermittently switched into passive mode by application of the telemetry wand, which is not mentioned in the manufacturer's description of the algorithm. This is particularly dangerous in the synchronous presence of RV noise, when therapy is not withheld and inappropriate shock delivered, as in our case. Therefore, in the case of any suspected (in)appropriate shock delivery, we propose to perform ICD interrogation with a parallel magnet application, to avoid and inhibit inappropriate shock deliveries during interrogation.

Conclusion

The above-presented case impressively illustrates the safety issue of the by-default programmed, automatic deactivation of the Abbott SecureSense algorithm during device interrogation. To avoid inappropriate ICD shock deliveries by RV noise signals, we suggest to perform Abbott ICD interrogation with parallel magnet application, whenever appropriate or inappropriate shock deliveries are suspected.

References

1. Moss AJ, Zareba W, Hall WJ, et al. Prophylactic implantation of a defibrillator in patients with myocardial infarction and reduced ejection fraction. N Engl J Med 2002;346:877–883.
2. Bardy GH, Lee KL, Mark DB, et al. Amiodarone or an implantable cardioverter-defibrillator for congestive heart failure. N Engl J Med 2005;352:225–237.
3. Powell BD, Asirvatham SJ, Perschbacher DL, et al. Noise, artifact, and oversensing related inappropriate ICD shock evaluation: ALTITUDE noise study. Pacing Clin Electrophysiol 2012;35:863–869.
4. Koneru JN, Kaszala K, Bordachar P, Shehata M, Swerdlow C, Ellenbogen KA. Spectrum of issues detected by an ICD diagnostic alert that utilizes far-field electrograms: clinical implications. Heart Rhythm 2015;12:957–967.
5. Beau S, Greer S, Ellis CR, et al. Performance of an ICD algorithm to detect lead noise and reduce inappropriate shocks. J Interv Card Electrophysiol 2016; 45:225–232.
6. Welte N, Strik M, Eschalier R, et al. Multicenter investigation of an implantable cardioverter-defibrillator algorithm to detect oversensing. Heart Rhythm 2017; 14:1008–1015.
7. van Rees JB, Borleffs CJW, de Bie MK, et al. Inappropriate implantable cardioverter-defibrillator shocks: incidence, predictors, and impact on mortality. J Am Coll Cardiol 2011;57:556–562.
8. Larsen GK, Evans J, Lambert WE, Chen Y, Raitt MH. Shocks burden and increased mortality in implantable cardioverter-defibrillator patients. Heart Rhythm 2011;8:1881–1886.
9. Morken IM, Isaksen K, Karlsen B, Norekvål TM, Bru E, Larsen AI. Shock anxiety among implantable cardioverter defibrillator recipients with recent tachyarrhythmia. Pacing Clin Electrophysiol 2012;35:1369–1376.
10. Volosin KJ, Exner DV, Wathen MS, Sherfesee L, Scinicariello AP, Gillberg JM. Combining shock reduction strategies to enhance ICD therapy: a role for computer modeling. J Cardiovasc Electrophysiol 2011;22:280–289.
11. Pérez Díez D, Rubín JM, Calvo Cuervo D, García Iglesias D, Morís De La Tassa C. Analysis of early failure of Biotronik Linox Smart implantable cardioverter-defibrillator leads: a comparative study of three defibrillator leads. Pacing Clin Electrophysiol 2018;41:1165–1170.
12. Weberndörfer V, Nyffenegger T, Russi I, et al. First time description of early lead failure of the Linox Smart lead compared to other contemporary high-voltage leads. J Interv Card Electrophysiol 2018;52:173–177.