The reverse mode switch algorithm: How well does it work?

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BACKGROUND The performance of the Reverse Mode Switch (RMS) algorithm, aimed at minimizing right ventricular pacing by operating in the AAI(R) mode with switch to the DDD(R) mode if atrioventricular (AV) conduction loss is detected, is not well known.

OBJECTIVE To determine the appropriateness of the RMS episodes available from patient follow-up data at our center.

METHODS Patients with the TELIGEN dual-chamber implantable cardioverter-defibrillator and the RMS algorithm activated were identified. The RMS episodes with available electrograms were analyzed and classified as appropriate (AV conduction loss) or inappropriate (non-AV conduction loss) events. Cumulative percentage of ventricular pacing and amount of premature ventricular complexes (PVCs) were recorded.

RESULTS Of 21 patients, RMS episodes had occurred in 19 of them, with a mean of 527 episodes per month. Of the 172 RMS episodes available for analysis, 27 (16%) were classified as appropriate and 145 (84%) as inappropriate. Almost all (91%) inappropriate RMS episodes were due to PVC, and there was a positive correlation between the number of total RMS episodes per month and the number of PVCs per month ($P < .0005$). Considering patients with only inappropriate RMS episodes ($n = 11$), there was a positive correlation between the percentage of ventricular pacing and the number of RMS episodes per month ($P < .05$).

CONCLUSIONS A large majority of the RMS episodes available for analysis inappropriately triggered switch from the AAI(R) mode to the DDD(R) mode owing to PVCs. Patients with the RMS algorithm and elevated PVC burden are probably at risk of a high percentage of unnecessary right ventricular pacing.

KEYWORDS Right ventricular pacing; Implantable cardioverter-defibrillator; AV conduction; Premature ventricular complex; Pacing mode

ABBREVIATIONS **%AP** = percentage of atrial pacing; **AV** = atrioventricular; **CRT** = cardiac resynchronization therapy; **EGM** = electrogram; **ICD** = implantable cardioverter-defibrillator; **LRL** = lower rate limit; **LVEF** = left ventricular ejection fraction; **MVP** = managed ventricular pacing; **PVC** = premature ventricular complex; **RMS** = Reverse Mode Switch; **RV** = right ventricular; **%VP** = percentage of ventricular pacing

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Introduction

Contrary to what is desirable in patients receiving cardiac resynchronization therapy (CRT) devices,[1] for patients receiving cardiac pacemakers or implantable cardioverter-defibrillators (ICDs) that do not require continuous pacing, the goal is to program the devices to minimize right ventricular (RV) pacing. There is strong evidence that long-term RV apical pacing leads to the deterioration of cardiac structure and function as well as an increased risk of heart failure and death, especially in those with previously reduced left ventricular ejection fraction (LVEF).[2,3] As a result, therapies that aim to reduce such negative effects, namely, CRT,[4] alternative pacing sites,[5] and specific pacemaker algorithms that minimize unnecessary RV pacing have emerged.[6–8] Algorithms that periodically prolong atrioventricular (AV) interval to search for, and permit, intrinsic AV conduction (AV hysteresis) were the first to be introduced.[6] More recently, algorithms that operate in a default atrial pacing mode (AAI(R)), with mode switch to the ventricular pacing mode (DDD(R)) in the case of loss of AV conduction, have been developed. Probably, the most studied is the managed ventricular pacing (MVP; Medtronic, Minneapolis, MN) algorithm, which has been found to significantly reduce RV pacing, when compared to the conventional DDD(R) mode.[7] Furthermore, in a randomized controlled trial of patients with sick sinus syndrome, the MVP algorithm was associated with a reduced risk of developing permanent atrial fibrillation when compared to DDD(R) pacing.[8]

Another atrial-based algorithm, aimed at minimizing RV pacing, is the Reverse Mode Switch (RMS) algorithm in the TELIGEN dual-chamber ICD family (Boston Scientific, St Paul, MN), recently replaced by RYTHMIQ (Boston Scientific, feature in the INCEPTA and ENERGEN dual-chamber ICD and the INGENIO dual-chamber pacemaker families).[9]

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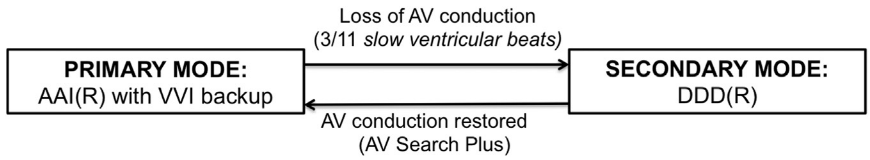

Figure 1 Description of the Reverse Mode Switch algorithm aimed at minimizing right ventricular pacing. It operates primarily in the AAI(R) mode, with VVI asynchronous backup pacing at the lower rate limit (LRL) −15, and switches from the AAI(R) mode to the DDD(R) mode if the loss of atrioventricular (AV) conduction is detected, which is defined as the presence of 3/11 *slow ventricular beats* that are any of the following: (1) ventricular paced beat (VP) or noise reversion VP event (by VVI backup); (2) ventricular sensed event with a V-V interval > AAI LRL + 150 ms (V-V is slower than the atrial rate but not slow enough to cause a VP); and (3) ventricular sensed event > AAI(R) sensor indicated rate + 150 ms (V-V is slower than the atrial rate but not slow enough to cause a VP). While in the DDD(R) mode, the AV Search Plus algorithm triggers switch from the DDD(R) mode to the AAI(R) mode if AV conduction is restored.

Of note, the only difference between these 2 algorithms are the presence of the atrial tachycardia response feature in the AAI(R) mode in RYTHMIQ (in the RMS algorithm, atrial tachycardia response was available only in the DDD(R) mode). In contrast to other algorithms that minimize RV pacing, there is currently no published data (clinical studies or case reports) on the performance of the RMS or RYTHMIQ algorithm. We assessed the appropriateness of the RMS episodes available from patient follow-up data at our center.

Methods

RMS algorithm description

The RMS algorithm, a feature of the TELIGEN dual-chamber ICD family (Boston Scientific, St Paul, MN), is available for DDD or DDD(R) modes only and is by default set to "OFF." It operates in the AAI(R) mode, with asynchronous backup VVI pacing at 15 ppm slower than the programmed lower rate limit (LRL) (nonprogrammable minimum and maximum rate of 30 and 60 ppm, respectively). The algorithm switches from the AAI(R) mode to the DDD(R) mode if the loss of AV conduction is detected, which is defined as the presence of 3 *slow ventricular beats* occurring in a window of 11 ventricular beats (Figures 1 and 2). While in the DDD(R) mode, the AV Search Plus algorithm is used to search for restored AV conduction defined as ≥25 ventricular sensed events with AV hysteresis. Therefore, for the device to return to the AAI(R) mode, the AV Search Plus algorithm must be activated (if the AV Search Plus algorithm is deactivated, the device would remain in the DDD(R) mode until further reprogramming). Owing to the low memory allocation priority given to the RMS algorithm, a maximum of 3 events with detailed reports including electrograms (EGMs) are stored. Upon device interrogation, these reports are erased from the device memory but can be saved to the programmer hard drive, a floppy drive, or a USB drive. In practical terms, this means that the number of RMS with EGMs available for analysis is limited and will depend on the frequency of device interrogations and whether the events are stored at the time of patient follow-ups. Nevertheless, the counter for the total number of RMS episodes cannot be reset and will therefore always indicate the total number of RMS events since device implantation.

Study group

This was a retrospective single-center analysis of information available from device interrogations of patients with an implanted TELIGEN dual-chamber ICD (Boston Scientific, St Paul, MN) that offered the RMS algorithm. All patients

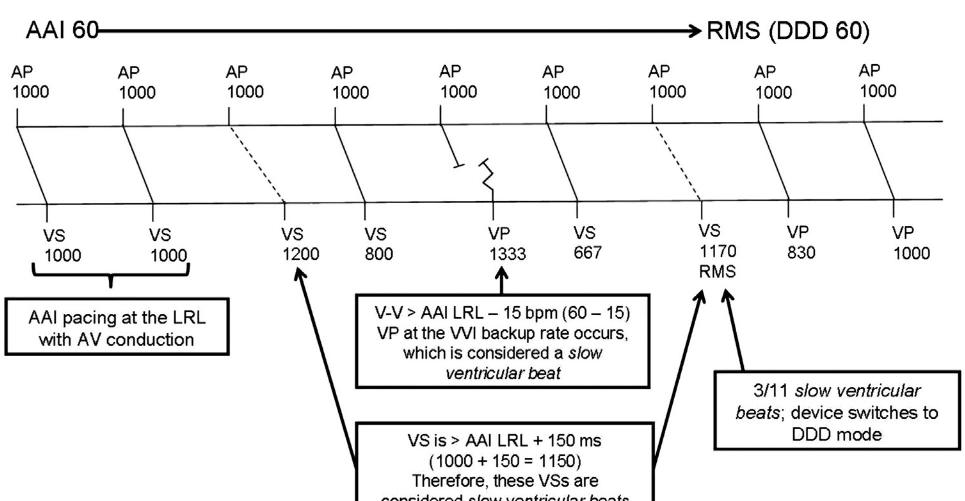

Figure 2 Schematic example of the functioning of the Reverse Mode Switch (RMS) algorithm. Atrioventricular (AV) conduction loss triggers switch from the AAI mode to the DDD mode through the detection of 3/11 *slow ventricular beats*. LRL = lower rate limit; VP = ventricular paced beat; VS = ventricular sensed beat.