Performance of a specific algorithm to minimize right ventricular pacing: A multicenter study

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BACKGROUND In Boston Scientific dual-chamber devices, the RYTHMIQ algorithm aims to minimize right ventricular pacing.

OBJECTIVE We evaluated the performance of this algorithm determining (1) the appropriateness of the switch from the AAI (R) mode with backup VVI pacing to the DDD(R) mode in case of suspected loss of atrioventricular (AV) conduction and (2) the rate of recorded pacemaker-mediated tachycardia (PMT) when AV hysteresis searches for restored AV conduction.

METHODS In this multicenter study, we included 157 patients with a Boston Scientific dual-chamber device (40 pacemakers and 117 implantable cardioverter-defibrillators) without permanent AV conduction disorder and with the RYTHMIQ algorithm activated. We reviewed the last 10 remote monitoring–transmitted RYTHMIQ and PMT episodes.

RESULTS We analyzed 1266 episodes of switch in 142 patients (90%): 207 (16%) were appropriate and corresponded to loss of AV conduction, and 1059 (84%) were inappropriate, of which 701 (66%) were related to compensatory pause (premature atrial contraction, 7%; premature ventricular contraction, 597 (56%); or both, 27 (3%)) or to a premature ventricular contraction falling in the post-atrial pacing ventricular refractory period interval (219, 21%) and 94 (10%) were related to pacemaker dysfunction. One hundred fifty-four PMT episodes were diagnosed in 27 patients (17%). In 85 (69%) of correctly diagnosed episodes, the onset of PMT was directly related to the algorithm-related prolongation of the AV delay, promoting AV dissociation and retrograde conduction.

CONCLUSION This study highlights some of the limitations of the RYTHMIQ algorithm: high rate of inappropriate switch and high rate of induction of PMT. This may have clinical implications in terms of selection of patients and may suggest required changes in the algorithm architecture.

KEYWORDS Pacemaker; RYTHMIQ; Dual; chamber; Right ventricle; Ventricular pacing; Dyssynchronopathy; AV block; AV conduction; Pacemaker algorithm; Boston Scientific

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Introduction

Right ventricular (RV) pacing is associated with deterioration of cardiac function and adverse cardiac remodeling.[1,2] Large clinical trials have shown that long-term RV pacing increases the risk of atrial fibrillation and heart failure.[3–5] Subsequently, pacemaker manufacturers have developed specific algorithms designed to minimize RV pacing by favoring intrinsic ventricular conduction in non–pacemaker-dependent patients.[6,7] The decreased pacing burden provided by these algorithms has been shown to reduce the incidence of atrial fibrillation and to increase the anticipated median device longevity.[8,9] In contrast, the ANSWER (EvaluAtioN of the SafeR mode in patients With a dual chambER pacemaker indication) study reports no effects on deaths, syncope, or the composite of hospitalization for heart failure, atrial fibrillation, or cardioversion, nor on the individual components.[10] The algorithms provided by each manufacturer vary in design and may be suitable for specific patient subgroups.

The RYTHMIQ algorithm, implemented in Boston Scientific dual-chamber pacemakers and implantable cardioverter-

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defibrillators, operates in the AAI mode with VVI backup pacing and switches to the DDD mode if loss of atrioventricular (AV) conduction is suspected. While in the DDD mode, the AV Search+ algorithm is used to search for return of AV conduction with periodic automatic extension of the AV interval. Increasing the AV interval has been associated with the development of pacemaker-mediated tachycardia (PMT).[11] However, there is currently little published data on the performance of the RYTHMIQ algorithm.[12]

In this multicenter study, we evaluated the performance of the RYTHMIQ algorithm assessing (1) the appropriateness of the RYTHMIQ events (switch from the AAI mode with backup VVI pacing to the DDD mode in case of suspected loss of AV conduction) and (2) the rate of recorded PMT when AV Search+ periodically checks for return of intrinsic conduction.

Methods

Selection of patients

In this observational French multicenter study, only patients with a Boston Scientific dual-chamber pacemaker (ACCOLADE, VITALIO, or INGENIO) or implantable cardioverter-defibrillator (AUTOGEN or INCEPTA) with RYTHMIQ algorithm activated and followed by remote monitoring were included. The RYTHMIQ algorithm was activated in patients with sinus node dysfunction, bradytachycardia syndrome, chronotropic incompetence, and paroxysmal AV block. The RYTHMIQ algorithm was systematically deactivated in patients with complete AV block and in patients with dual-chamber implantable cardioverter-defibrillators with no pacing needs (who were programmed to VVI mode at 40 beats/min). Patients with permanent atrial fibrillation or complete permanent AV block were excluded. All patients gave written informed consent for the analysis of the data collected from remote monitoring, and patient information was de-identified before the analysis of the episodes.

Description of the RYTHMIQ algorithm

The RYTHMIQ algorithm is available for DDD or DDD(R) modes only and requires to be switched on.

Primary pacing mode: AAI(R) with VVI backup

This algorithm provides AAI(R) pacing with asynchronous VVI backup pacing. The 2 modes operate nearly independently from one another, but to avoid cross talk, atrial pacing generates ventricular refractory periods (blanking and noise windows). Ventricular pacing is delivered only when the heart rate decreases below 15 beats/min (fixed value) lower than the programmed lower rate limit (LRL) with a minimal value of 30 beats/min (for LRL $<$ 45 beats/min, the VVI backup LRL will be 30 beats/min) and a maximal value of 60 beats/min (for LRL $>$ 75 beats/min, the VVI backup LRL will be 60 beats/min).

Switch from the AAI(R) to the DDD(R) mode

The device switches from the AAI(R) to the DDD(R) mode when 3 slow ventricular beats are detected in a window of 11 beats. A *slow ventricular beat* is defined as a ventricular paced (VP) beat (by VVI backup pacing), a VP due to noise response, a VS(ventricle sensed)-VS interval of at least 150 ms longer than the LRL (interval is smaller than the atrial rate, but not small enough to trigger a VP), or a VS-VS interval of at least 150 ms longer than the AAI(R) sensor–indicated rate (interval is smaller than the atrial rate, but not small enough to trigger a VP).

AV Search+

In the DDD(R) mode, the algorithm uses the AV Search+ to periodically check for return of intrinsic conduction. After a certain number of cardiac cycles in the DDD mode (default value at 32 cycles), the AV Search Interval is activated and the AV delay is extended to the programmed AV Search+ value (default value 300 ms). If a Vsense is detected within the 8-cycle period of AV Search+ (primary phase), hysteresis continues in the secondary phase. The AV Conduction Detector Counter is initialized at "0" and is incremented by each ventricular sensed event (marked as VS-Hy). When the AV Conduction Counter has reached 25, sustained conduction is detected and the device switches back to the primary AAI(R) mode with VVI backup. The device maintains DDD (R) pacing and does not switch back to the AAI(R) mode when no intrinsic conduction is detected within the first 8-cycle search period (primary phase) or when 2 of the last 10 ventricular events are paced (sliding window during the secondary phase).

Recording of a RYTHMIQ switch episode

The mode switch to DDD(R) is recorded in the Arrhythmia Logbook as a RYTHMIQ episode; a 20-second electrogram (EGM) is stored (10 seconds before and 10 seconds after the switch to DDD). The number of EGMs available for the analysis is limited owing to the low memory allocation priority. The counter for the total number of RYTHMIQ switch episodes cannot be reset and indicates the total number of events since device implantation.

Description of the PMT termination algorithm

The PMT termination algorithm is applied when 16 consecutive AS(atrium sensed)-VP cycles occur at the maximum tracking rate and the associated ventriculoatrial intervals do not vary by more than 32 ms. The post-ventricular atrial refractory period (PVARP) is extended to 500 ms for 1 cycle after the 16th VP beat, aiming to terminate retrograde ventriculoatrial conduction.

Data analysis

We reviewed up to 10 of the most recent remote monitoring–transmitted EGMs of RYTHMIQ events and determined the appropriateness of the mode switch. Similarly, we reviewed up to 10 of the last remote monitoring–transmitted EGMs of PMT.