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Interruption of cardiac resynchronization therapy by atrial premature complexes

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Abstract Biotronik devices used for cardiac resynchronization therapy (CRT) combined with defibrillation function (CRT-D) are capable of left ventricular (LV) sensing. Under certain circumstances, LV sensing may cause loss of CRT. The third generation of the Biotronik i-family CRT-Ds enables the recording of event-triggered tracings of the electrogram particularly those involving "CRT pacing interrupt" episodes. We report three cases of a sudden "CRT pacing interrupt" initiated by an atrial premature complex. This was caused by realignment of the LV timing cycles induced by the APCs whereupon LV pacing was inhibited and a self-perpetuating desynchronization process was initiated. In all cases it is the repeated occurrence of LV sensed events that prevents the emission of LV paced events because it displaces the LV upper rate interval from its normal position. Prevention of desynchronization requires programming an LV upper rate faster than the maximum sensor-driven rate or right ventricular upper rate.

Keywords: Cardiac pacing; Cardiac resynchronization therapy; CRT; Atrial premature complex; Desynchronization; Left ventricular sensing

Some devices used for cardiac resynchronization therapy (CRT) combined with defibrillation function (CRT-D) are capable of left-ventricular (LV) sensing [1]. Under special circumstances, LV sensing in such devices predisposes them to develop sudden desynchronization at pacing rates far below the programmed maximum sensor-driven rate or upper tracking rate (UTR). Such desynchronizing events include ventricular premature complexes (VPC), atrial under- or oversensing, and occasional loss of LV capture [1].

The third generation of the Biotronik i-family CRT-Ds (Intica, Ilivia, Inlexa) enables the recording of event-triggered tracings of the electrogram (EGM) involving "CRT pacing interrupt" episodes, non-sustained VTs, and clusters of non-physiological short intervals in case of a malfunctioning lead [2,3] These recordings of event-related electrograms have uncovered previously unknown scenarios, causes and frequency of desynchronization.

We report three cases of a sudden "CRT pacing interrupt" initiated by an atrial premature complex (APC). "CRT pacing interrupt" is defined as desynchronization caused by inhibition of left ventricular pacing based on realignment of the timing cycles induced by the APCs.

Material and methods

All patients received Biotronik devices (Table 1) (Biotronik SE & Co. KG, Berlin, Germany) [2,3]. All were programmed with the left ventricular (LV) T-wave protection function turned on to promote LV sensing. A "CRT pacing interrupt" is defined if the detection criterion based on '20 out of 48' is fulfilled. The algorithm checks within a sliding window of 48 right-ventricular cycles [both RV paced events (RVp) and RV sensed events (RVs), but no VPCs], whether at least 20 left-ventricular paced events are inhibited because inside the left-ventricular upper rate interval (LVURI). In the recorded "CRT pacing interrupt" episodes, the restoration of resynchronization is not documented because the LVURI lock-in lasted longer than the recording duration of 30 s for any given episode. Multiple episodes of "CRT pacing interrupt" by APCs were recorded in all patients by home monitoring and only representative examples are analyzed herein. The AV control (AVC) interval of Biotronik CRT-D devices is a special

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Table 1
Patient characteristics.

Case	Mechanism	Mode	RV upper tracking rate [ppm]	Maximum sensor rate [ppm]	LV maximum trigger rate [ppm]	V-V [ms]	IVC [ms]	Critical rate [/min]
1	RVp – LVs	DDDR	130 (460 ms)	100 (600 ms)	100 (600 ms)	0	280	68 (880 ms)
2	RVp – LVs	DDDR	130 (460 ms)	120 (500 ms)	120 (500 ms)	0	220	83 (720 ms)
3	RVs – LVs	DDD	130 (460 ms)	–	150 (400 ms)	40	110	109 (550 ms)

RV = right ventricle, LV = left ventricle, RVp = right ventricular paced event, RVs = right ventricular sensed event, LVs = left ventricular sensed event, LV maximum triggered rate = LV upper rate, V-V = programmed interventricular delay, IVC = spontaneous interventricular conduction time (RVp – LVs or RVs – LVs).

ventricular timing interval to identify device-defined VPCs after an atrial event (default 350 ms) [1]. A ventricular sensed (Vs) event in the AVC window (starting with an atrial event) is classified as a non-VPC sensed right ventricular event (RVs). An RV sensed event beyond the AVC window is identified as a VPC (RVEs). The AVC window starts with an atrial sensed event (As), an atrial pace event (Ap), and an atrial event that is sensed within the postventricular atrial refractory period [As (PVARP)]. Typically, a Vs or ventricular paced event (Vp) terminates the AVC window.

Case 1. This patient received an Inlexa 3 HF-T QP CRT-D device programmed as follows (Table 1): biventricular DDDR mode, lower rate 60 ppm, right ventricular (RV) upper tracking rate 130 ppm, rate adaptive AV-delay 150–120 ms with sense compensation of - 40 ms, maximum sensor rate 100 ppm, left ventricular (LV) maximum trigger (upper) rate 100 ppm, V-V delay 0 ms. One of the documented "CRT pacing interrupt" episodes is shown in Fig. 1. At the beginning, biventricular pacing is visible at a sensor-driven pacing rate of 86 ppm (700 ms). Then, an

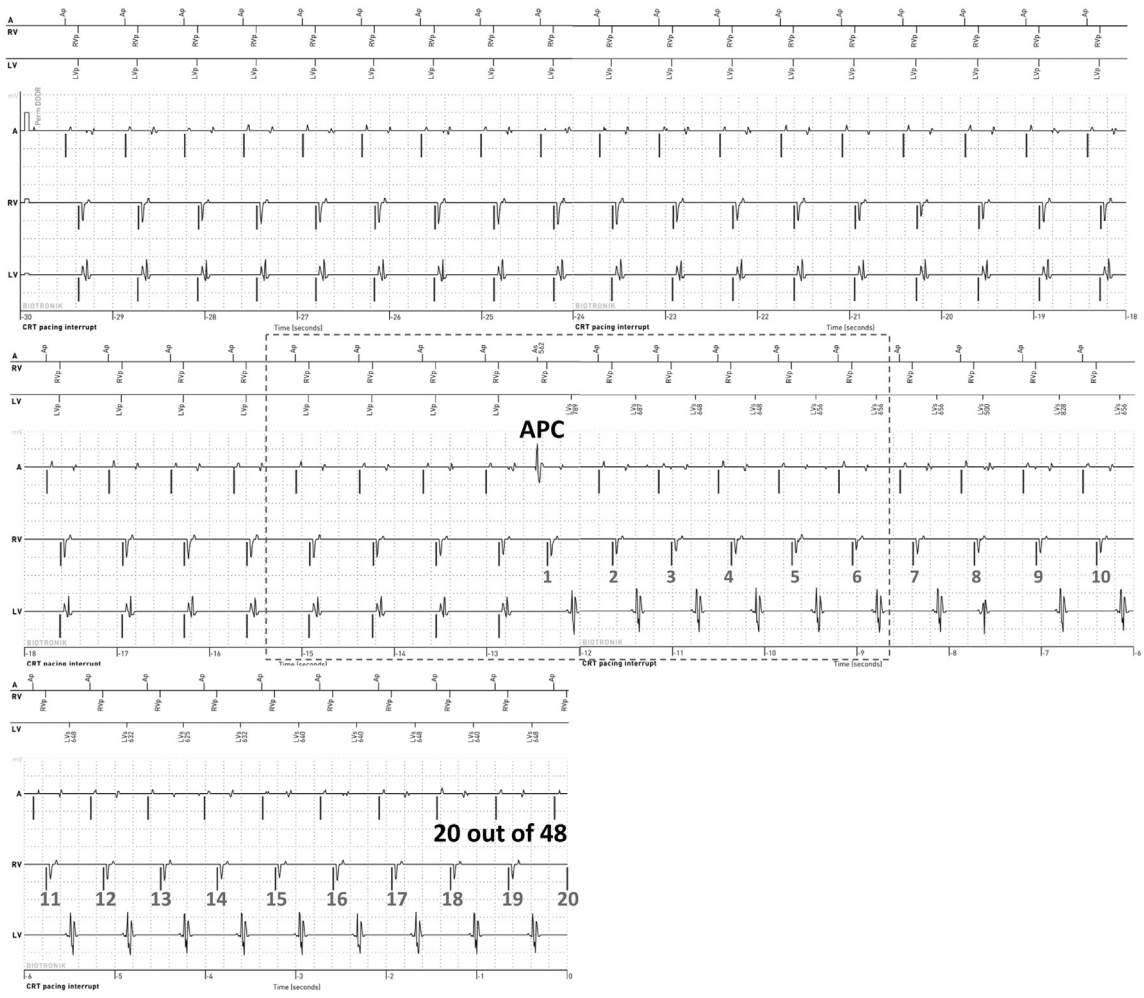

Fig. 1. Case 1. Recording from a patient with a Biotronik Inlexa 3 HF-T QP device. Resynchronization was suddenly interrupted by a single atrial premature complex (APC). The marker channels are shown on top (A = atrial; RV = right ventricle; LV = left ventricle). The lower part of the recording shows the atrial electrogram (A), RV electrogram (RV), and the LV electrogram (LV). Desynchronization persists although the sensor-driven pacing rate of 86 ppm is below the maximum sensor rate of 100 ppm. See text for details.