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Atrial electrogram quality in single-pass defibrillator leads with floating atrial bipole in patients with permanent atrial fibrillation and cardiac resynchronization therapy

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ABSTRACT

Many patients receiving cardiac resynchronization therapy (CRT) suffer from permanent atrial fibrillation (AF). Knowledge of the atrial rhythm is important to direct pharmacological or interventional treatment as well as maintaining AV-synchronous biventricular pacing if sinus rhythm can be restored. A single pass single-coil defibrillator lead with a floating atrial bipole has been shown to obtain reliable information about the atrial rhythm but has never been employed in a CRT-system. The purpose of this study was to assess the feasibility of implanting a single coil right ventricular ICD lead with a floating atrial bipole and the signal quality of atrial electrograms (AEGM) in CRT-defibrillator recipients with permanent AF.

Methods and results: Seventeen patients (16 males, mean age 73 ± 6 years, mean EF 25 ± 5%) with permanent AF and an indication for CRT-defibrillator placement were implanted with a designated CRT-D system comprising a single pass defibrillator lead with a atrial floating bipole. They were followed-up for 103 ± 22 days using remote monitoring for AEGM transmission. All patients had at last one AEGM suitable for atrial rhythm diagnosis and of 100 AEGM 99% were suitable for visual atrial rhythm assessment. Four patients were discharged in sinus rhythm and one reverted to AF during follow-up.

Conclusion: Atrial electrograms retrieved from a single-pass defibrillator lead with a floating atrial bipole can be reliably used for atrial rhythm diagnosis in CRT recipients with permanent AF. Hence, a single pass ventricular defibrillator lead with a floating bipole can be considered in this population.

1. Background

Cardiac resynchronization therapy (CRT) has been shown to reduce morbidity and mortality in symptomatic heart failure patients on optimal medical therapy with left bundle branch block and a left ventricular ejection fraction ≤35% [1,2]. The bulk of evidence has been generated in patients in sinus rhythm.

Up to one third of heart failure patients are in persistent or permanent atrial fibrillation (AF). There is evidence that these patients do benefit from CRT if intrinsic atrioventricular (AV) nodal conduction is completely blocked by AV-node ablation [3,4] and therefore most CRT candidates with permanent AF receive CRT today [5,6].

Since atrial stimulation is not possible in permanent AF, many operators only implant a right and a left ventricular lead, thereby evading the risk of atrial lead placement like dislodgements. Knowledge of the atrial rhythm may be nonetheless important, since some patient will revert to sinus rhythm under CRT [7]. Any sort of atrial sensing then allows for AV-synchronous biventricular pacing. Furthermore, with regular remote monitoring transmission of atrial intracardiac electrograms (AEGM), an early appreciation of sinus rhythm may be facilitated [8].

Recently, a single-pass single-coil defibrillator lead with a

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floating atrial bipole has been shown to obtain reliable information of the atrial rhythm in patients receiving a single chamber ICD without CRT [9].

The purpose of this study was to assess the signal quality of AEGM in CRT-D recipients with permanent AF implanted with a single coil right ventricular ICD lead with a floating atrial bipole. AEGMs were analysed both as received from the programming device and as transmitted by remote monitoring.

2. Methods

2.1. Study population

Between August 2013 and June 2014 17 patients with permanent atrial fibrillation, heart failure NYHA class III/IV, QRS width $\geq$120 ms and a mean ventricular rate $\leq$60 bpm at rest or $\leq$90 bpm at exercise or pacemaker dependency as a result of planned AV junction ablation [5,10], and left ventricular ejection fraction $\leq$ 35% were implanted with a CRT-D in 3 sites in Germany and Switzerland. Local ethics review committees at each center approved the study and informed consent was obtained from all participants. The trial was funded by Biotronik SE (Berlin/Germany) and registered at ClinicalTrial.gov number, NCT01930605.

2.2. Device specification

Patients received a designated CRT-D device (Biotronik Lumax 640/740 DX, Biotronik SE, Berlin, Germany) with a specific 4-fold preamplifier for the atrial sensing signal and no atrial pacing capability. This device was connected to a single-coil right ventricular defibrillation lead with two floating atrial ring electrodes 15 or 17 cm proximal to the RV tip (Biotronik Linox Smart S DX, Biotronik SE, Berlin, Germany). The devices were equipped with remote monitoring (Biotronik Home Monitoring©) with the ability to transmit one three-channel IEGM per day either scheduled by programming or if a spontaneous episode of arrhythmia occurred. The devices record the "atrial burden" (AB) as the percentage of the time in which the atrial rate is above 200 beats per minute, and transmit the result of the last 24 h by Home Monitoring. AB figures were imported from the HM service center and averaged for the periods from implantation to the 1 month follow-up, and from the 1 month to the 3 months follow-ups.

2.3. Implantation and follow-up

Implantations were performed according to institutional standards. All patients received the Linox Smart S DX right ventricular lead and a transvenous left-ventricular lead, but no separate atrial lead. Leads were connected to a designated CRT defibrillator with optimized filter settings for atrial signal processing. The devices were programmed to the VVI or VVIR (for patients with bradycardic AF) pacing mode but atrial IEGM acquisition and transmission was activated in all patients. Study participants were followed-up for three months.

AEGMs were retrieved by device interrogation at implantation, discharge, after 1 month and after 3 months. Furthermore, periodic transmission of AEGMs by Home Monitoring was scheduled on days 3 and 20 after discharge from hospital, and every 20 days after the one-month follow-up. AEGMs were also analysed when an event triggered transmission was available (theoretically numerous, but the maximal real number was 3 during the three-month study period). Biotronik Home Monitoring© does allow for the transmission of periodic AEGMs only when the patient is near the transmission station at the time of EGM recording, as no memory possibility is available in the system. This explains why these periodic EGMs are not available in all the patients all of the time points. For all AEGMs, whether retrieved by programmer or transmitted by Home Monitoring, two investigators independently decided whether or not it was possible to judge the atrial rhythm, and which atrial rhythm was present. These investigators were blinded to other potentially available ECG or electrogram tracings of the respective patients.

2.4. Endpoints

The first endpoint was the percentage of patients with at least one AEGM suitable for atrial diagnosis within the study period of three months. The second endpoint was the proportion of AEGM suitable for atrial diagnosis and the third the number of patients found in sinus rhythm based on the AEGM. During follow-up visits, the AEGM diagnosis was confirmed by 12-lead ECGs.

3. Results

The study population consisted of 17 patients, predominantly male (94%), with a mean age of 73 ± 6 years, and a mean EF of 25 ± 5%). They were followed for 103 ± 22 days. The mean duration of AF before implantation was 43 ± 40 months and 5 patients underwent scheduled AV-node ablation (Table 1). During the follow-up no antitachycardia therapies for ventricular tachyarrhythmias were delivered by the ICD.

3.1. Atrial EGM

In the 17 remaining patients, 100 AEGM (2–11 per patient) were analysed. All patients had at least one AEGM that was suitable for atrial diagnosis. 99 out of 100 (99%) AEGM allowed for rhythm diagnosis (Figs. 1 and 2).

Four patients (patients1/3/4/15, 23%) were discharged in sinus rhythm after cardioversion during defibrillation threshold testing. All of them had sinus rhythm confirmed in a first scheduled Home Monitoring transmission 3 days after discharge. After one month, 3 of these patients were still in sinus rhythm and another converted spontaneously to sinus rhythm. The rhythm diagnosis of the AEGM was congruent with the rhythm found during FU using a 12 lead ECG in all cases. However, signal amplitudes in some patients were too low and variable to be used for automated algorithms. This explains why the burden is not 100% in certain patients who were always in AF on every single documented ECG or AEGM.

Table 1
Patient demographics.

Patient characteristic	
Male	16 (94%)
Age (years)	73 ± 6
LVEF (%)	25 ± 5
AF duration (months)	43 ± 40
Mean heart rate (bpm)	79 ± 23
QRS duration (ms)	160 ± 27
Left bundle branch block (n)	13 (76%)
NYHA class II/III/IV	0/16/1
AV-node ablation	5 (29%)
Ischemic cardiomyopathy	7 (41%)
Primary preventive indication	17 (100%)
Hypertension	16 (94%)
Oral anticoagulation	15 (88%)
Amiodarone	4 (24%)
Beta-Blocker	14 (82%)

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