Analysis of Atrial Conduction Times with Single Lead Stimulation

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Summary

The prevention of atrial tachyarrhythmias has become an increasingly explored field of research, such as multi-site or biatrial stimulation. Both methods shorten inter- and intraatrial conduction times as a prophylaxis for atrial flutter or fibrillation. In this retrospective pilot study involving 8 patients, single lead DDD stimulation is suggested as a simple and less burdening preventive pacing method. The results show that with global depolarization a shortening of atrial conduction times from 168 ± 29 ms to 130 ± 24 ms was possible in patients with pathologically long P waves. Further reductions in P-wave durations could not be achieved in patients possessing P-wave values in the normal range.

Key Words

Single lead pacing, multi-site stimulation, biatrial stimulation, tachycardia prevention, inter- and intraatrial conduction times

Introduction

To date, the primary application of single lead dual-chamber pacing was to re-establish AV synchrony in the therapy of bradyarrhythmias with a pacemaker-electrode system that possessed simplified handling [3,5,6,9]. With this method, the need for an atrial lead is eliminated as is the effort to find an adequate location for the electrode tip in the right atrium (RA). Atrial stimulation ensues with an electrical far-field emitted by fractal coated, floating atrial ring electrodes that are housed on the right ventricular lead (Figure 1). However, within the context of the recent research on atrial tachyarrhythmia prevention, the concept of far-field atrial pacing offers new possibilities as will be discussed in this paper.

For prevention of atrial tachyarrhythmias by pacing several methods have been introduced up to now, including multi-site right atrial pacing (MSP) and biatrial pacing (BAP) using the coronary sinus approach. In MSP, simultaneous local depolarization (via two leads located at different points of the right atrium and an adequate interelectrode distance) yielded strikingly reduced right atrial P-wave durations [7,8]. By pacing simultaneously in both the right and left atria, as in BAP, interatrial conduction times are shortened and, consequently, the prevalence of atrial tachycardias is significantly reduced [1,2,4,10]. To summarize, the aim of these methods is to decrease the intra- and interatrial conduction times and, furthermore, to avoid dispersion of refractory periods in different parts of the right and left atria. Thus, shortening pathologically long P waves is one of the main measures of success for these pacing methods.

As an alternative method, based on the assumption of a global depolarization effect in the atria - as achieved by far-field stimulation from a right atrial dipole - a retrospective study was performed during standard follow-up investigations in patients who were previously implanted with the single lead pacemaker systems. The goal was to observe inter- and intraatrial conduction times during single lead DDD pacing; these parameters were expected to be greater reduced during atrial paced activities compared to spontaneous

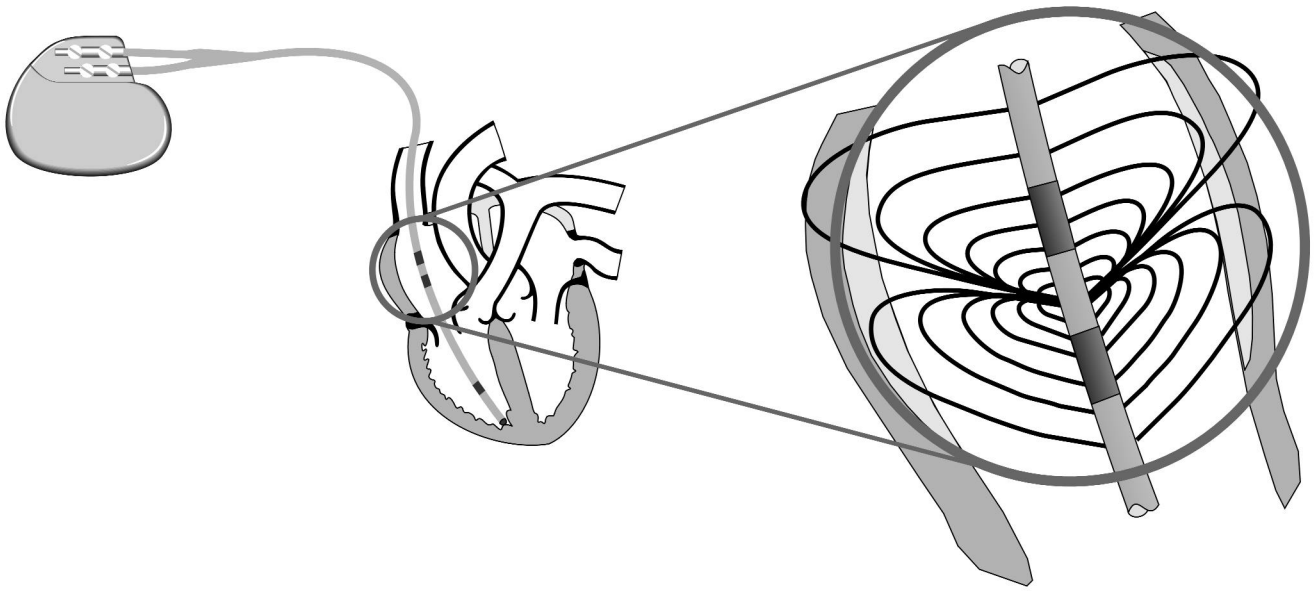

Figure 1. Atrial stimulation with a floating dipole on a single pass lead: global depolarization is achieved with an electrical far-field.

ones, thus providing a preventative effect, as in MSP or BAP.

Materials and Methods

In 8 patients (1 female, 7 male) with a mean age of 73 ± 7 years (range: 66 to 85 years), single lead dual-chamber systems (Eikos SLD or Dromos SL M7, BIOTRONIK) were implanted with the respective single pass leads (SL 60-UP/11, 13, 15; BIOTRONIK). During implantation, the atrial dipole was positioned according to optimal sensing and pacing values and the guidelines for implantation of single lead dual-chamber systems. At the time of implantation, no special attention was paid to securing an advantageous location for atrial tachyarrhythmia prevention.

Mean follow-up time was 16 ± 8 months (range: 3 to 30 months). As a part of the standard pacemaker follow-up examination, P- and R-wave amplitudes and atrial and ventricular thresholds were attained. Additionally, for the purposes of this retrospective study, inter- and intraatrial conduction times were measured. To this end, surface electrograms (ECG) and intracardiac electrograms (IEGM) were recorded during two pacemaker modes (VDD, DDD). For atrial pacing, the overlapping biphasic (OLBI) configuration was used with pulses of 4.8 V at a pulse width of 0.5 ms. To capture the electrical activity of the left atrium, a hexapolar lead was used to record the esophageal ECG. Information regarding the right atrial activity was extracted from the esophageal ECG and surface ECG leads (I, II, III, V1). The IEGM was recorded in parallel. Atrial activation times were extracted from the ECG recordings.

In detail, the following measurements were taken using ECGs during VDD pacing:

1. Right atrial activation times (RAAT), starting with the onset of the P wave in the surface ECG and ending with the first zero-crossing;
2. Left atrial activation times (LAAT), starting with the first zero-crossing in the surface (or esophagus) ECG and ending with reaching a base-line signal or the ventricular spike (in cases of very long P waves) in the esophagus ECG respectively;
3. Total atrial activation time (TAAT), i.e., the total P-wave duration, starting with the begin of RAAT and finishing with the end of LAAT.

The following measurements were taken using ECGs during DDD pacing:

1. The duration from the atrial spike (S) to the onset of the P wave;
2. RAAT;

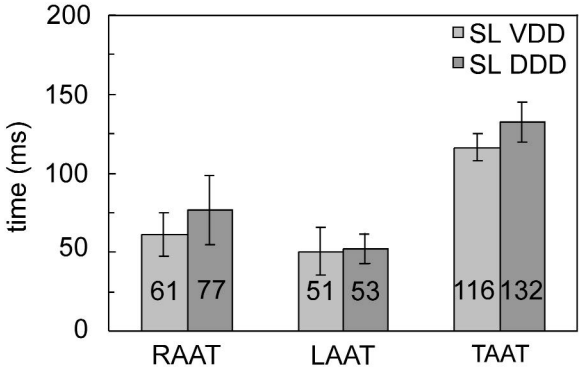

Figure 2. RAAT, LAAT and TAAT in 4 patients with normal P-wave durations.

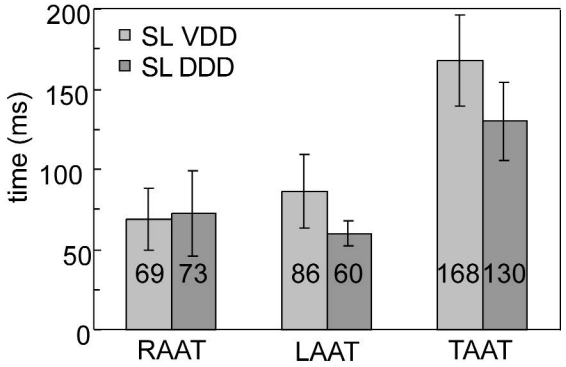

Figure 3. RAAT, LAAT and TAAT in 4 patients with pathological P-wave durations during VDD/DDD pacing.

3. The duration from the atrial spike to the beginning of left atrial activity;
4. LAAT;
5. TAAT; in order to obtain comparable values for DDD and VDD pacing, the atrial latency time is not included in the TAAT for DDD pacing.

Results

The mean right atrial P-wave amplitude in 8 patients was 1.2 ± 0.8 mV (range: 0.3 - 1.9 mV). The atrial OLBI pacing threshold was 3.3 ± 0.4 V at 0.5 ms (range: 2.6 - 4.0 V). No diaphragmatic stimulation or other secondary stimulation effects occurred throughout follow-up.

Group 1 (n = 4) showed an normal P-wave duration of 116 ± 9 ms during VDD stimulation. This value could not be further shortened in the DDD mode, rather the mean P-wave duration was increased to 132 ± 19 ms. The intraatrial conduction times for the right and left atria and the total atrial activation times (RAAT, LAAT, TAAT) are shown in Figure 2 for this patient group.

Group 2 (n = 4) showed pathologically long P-wave durations; atrial pacing shortened this parameter from 168 ± 29 ms to 130 ± 24 ms (Figure 3). During VDD pacing, LAAT was 86 ± 23 ms; during DDD pacing 60 ± 8 ms. The mean RAAT during DDD and VDD pacing did not show a noteworthy difference.

Figures 4 through 6 show segments extracted from ECG and IEGM recordings from a group 2 patient during single lead VDD and DDD stimulation. The atrial pulse amplitude was 4.8 V at 0.5 ms, and efficacy of atrial pacing was 100%. The TAAT value was 150 ms during VDD pacing, and 120 ms during DDD pacing. Due to intra-individual variations of the dipole positions, depolarization was not equally fast in all patients but nonetheless within a reasonable range. As shown in the results from Figure 3, the TAAT is mainly reduced by a shortened LAAT.

Figure 4. Continuous atrial capture monitoring with IEGM and surface ECG recordings.

Discussion

In light of the methods suggested to date and applied in the prevention of atrial tachyarrhythmias, single lead DDD pacing provides considerable advantages. Single lead pacing is a simple and viable concept that poses less a burden to the patient. Within the last four years, several studies have investigated and proven the safety and reliability of this method for bradycardia therapy, i.e., borderline VDD/DDD indications such as over-

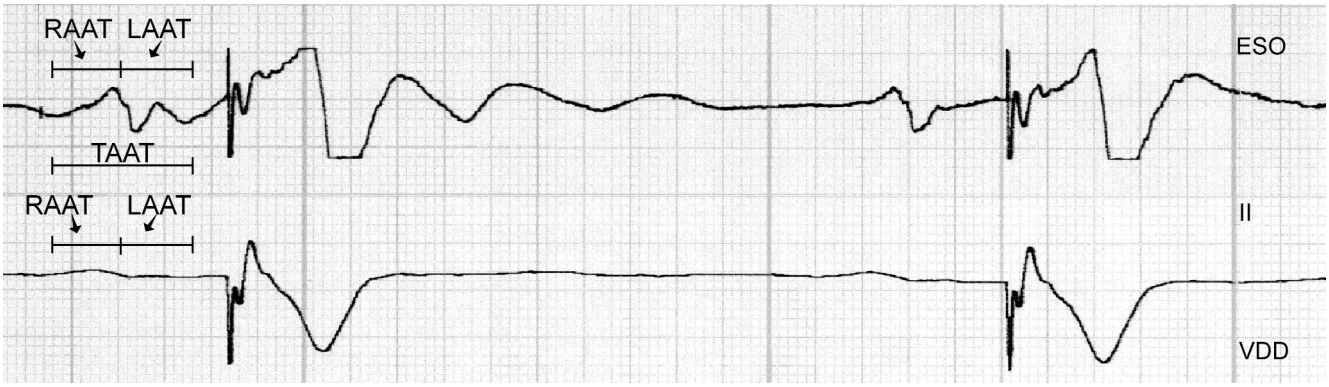

Figure 5. Typical ECG trace during single lead VDD stimulation. TAAT: 150 ms; RAAT: 70 ms; LAAT: 80 ms. Both esophageal (ESO) and surface (II) ECG leads must be used to determine the respective periods.

night bradycardia or low rates due to cardio-depressive medication in patients with 2nd or 3rd degree AV blocks.

Based on these positive results, applying this method in the field of preventive atrial pacing is conceivable. This pilot study shows that single lead DDD stimulation yields reduced atrial activation times in patients with pathologically long P-wave durations, thus laying the groundwork for verifying the effects of global depolarization afforded by far-field stimulation. An additionally remarkable point is that, independent of the duration of the intrinsic P wave, a total atrial activation time of 131 ± 17 ms was observed in all patients during single lead DDD stimulation. Thus, the main principle of activation seems to be unaffected by the pathological circumstances regarding the spread of excitation. The total atrial activation time with single lead DDD pacing remains within an almost constant range, providing a measure for an indication of such a system. Patients with 2nd or 3rd degree AV blocks and abnormally long P-wave durations (above 140 ms) would be ideal candidates for this method.

Naturally, the retrospective character of this study also has to be taken into consideration in examining the results. No measures were taken to secure optimal positions of the atrial ring electrodes with respect to the global depolarizing effect that also includes the left atrium. Consequently, the right and left atrial activation times may be perhaps even further reduced by placing the rings in a location closer to the atrial

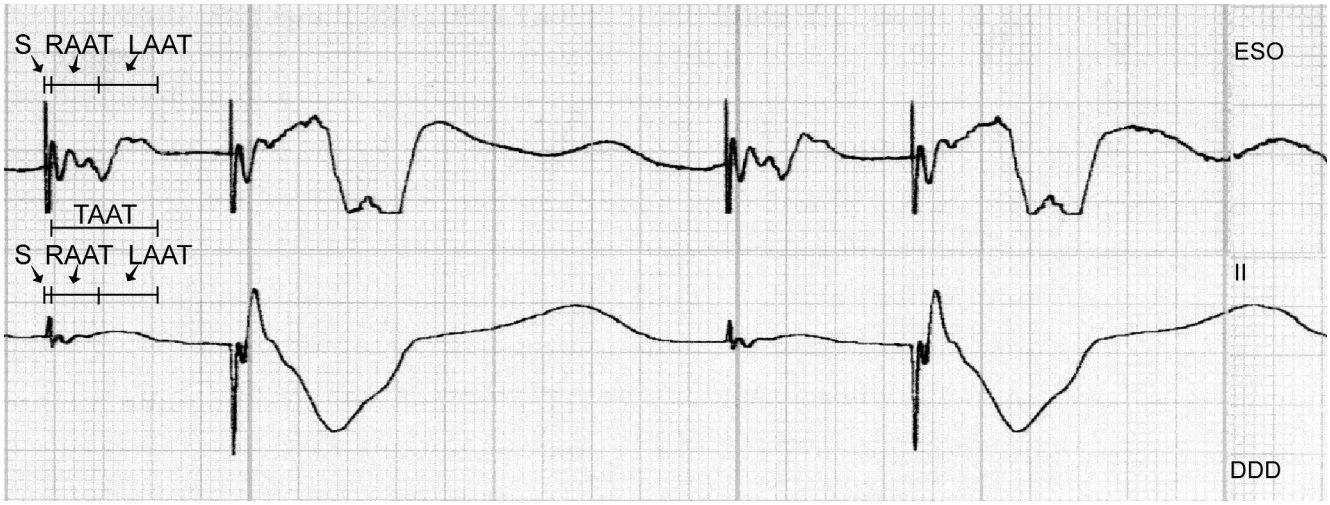

Figure 6. ECG recording (of the same patient from Figures 4 and 5) during DDD OLBI stimulation at 4.8 V and 0.5 ms. TAAT decreased from 150 ms to 120 ms as compared to VDD pacing. RAAT and LAAT values were each 60 ms, yielding a stronger LAAT influence on TAAT shortening (S: spike).

septum. To this end, a new lead design that would provide more flexibility in atrial ring positioning is worth consideration.

Conclusion

The present results of this pilot study suggest a new method for the prevention of atrial tachyarrhythmias. Single lead DDD stimulation not only provides dual-chamber bradycardia therapy that is simple and less burdensome to the patient, but it also uses the concept of global depolarization to reduce the prevalence of atrial tachyarrhythmias resulting from intra- and interatrial conduction disturbances. Additional prospective studies with patients possessing the proper indications (e.g., P-wave duration > 140 ms) should be conducted in order to verify the results of this investigation. Also, attention should be focused on optimizing the lead, e.g., by shaping the atrial portion with respect to a more septal positioning of the atrial dipole for almost simultaneous capture of both atria.

References

[1] Daubert JC, Gras D, Berder V, et al. Resynchronisation atriale permanente par la stimulation biatriale synchrone pour le traitement préventif du flutter auriculaire associé à un bloc interauriculaire de haut degré. Arch Mal Coeur. 1994; 87: 1535-1546.

[2] Daubert JC, Leclercq JF, Pavin D, et al. Biatrial synchronous pacing: A new approach to prevent arrhythmias in patients with atrial conduction block. In: Prevention of tachyarrhythmias with cardiac pacing. Daubert JC, Prystowsky EN, Ripart A (eds). Armonk, NY: Futura Publishing; 1997: 99-119.

[3] Del Guidice G, Frabetti L, Cioffi L, et al. DDD pacing using a single AV lead with atrial floating dipole and overlapping biphasic stimulation. In: Europace '97. Vardas P (ed). Athens: Monduzzi Editore; 1997: 851-856.

[4] Kutarski A, Poleszak K, Oleszak K, et al. Biatrial and coronary sinus pacing - long-term experience with 264 patients. Prog Biomed Res. 1998; 3 (3): 114-120.

[5] Lucchese FA, Schaldach M. Effect of Valsalva maneuver and body position on atrial capture performance using single lead DDD OLBI stimulation. Results of the BRASILEAD project. In: Europace '97. Vardas P (ed). Athens: Monduzzi Editore; 1997: 357-362.

[6] Rey JL, El Ghelbazouri F, et al. Dual chamber pacing with a single lead system: Initial clinical results. Pacing Clin Electrophysiol. 1996; 19 (II): 1777-1779.

[7] Saksena S, Delfaut P, Prakash A, et al. Multi-site electrode pacing for prevention of atrial fibrillation. J Cardiovasc Electrophysiol. 1998; 9 (8): 155-162.

[8] Saksena S, Prakash A, Hill M, et al. Prevention of recurrent atrial fibrillation with chronic dual-site right atrial pacing. J Am Coll Cardiol. 1996; 28 (5): 687-694.

[9] Tse HF, Lau CP, Leung SK, et al. Single lead DDD system: A comparative evaluation of unipolar, bipolar, and overlapping biphasic stimulation and the effects of right atrial floating electrode location on atrial pacing and sensing thresholds. Pacing Clin Electrophysiol. 1996; 19 (11 Pt 2): 1758-1763.

[10] Witte J, Reibis R, Bondke HJ, et al. Permanent biatrial pacing as a therapeutic alternative for drug refractory (idiopathic, lone, isolated) atrial fibrillation. In: Rhythm control from cardiac evaluation to treatment. Adornato E (ed). Rome: Edizione Luigi Pozzi; 1998: 336-342.