Single-Lead DDD Pacing: Is There a Difference Between a Right and Left Subclavian Approach?

C.M.C. VAN CAMPEN, C.C. DE COCK, H.S. VOS, F.C. VISSER, C.A. VISSER
Department of Cardiology, Academic Hospital VU, Amsterdam, The Netherlands

Summary

Dual-chamber pacing with a single lead offers potential benefits over conventional dual-chamber pacing via two leads with respect to lower device costs, ease of implantation, and a reduction in the complication rate, especially related to atrial lead fixation. Despite respectively lower atrial pacing thresholds using overlapping biphasic impulse (OLBI) pacing, a relatively high incidence of loss of atrial capture is still reported. This is related to the distance of the floating atrial electrode to the right atrial wall. Lead implantation using the right versus left subclavian vein approach may result in a different position of the atrial dipole. The aim of this study was to compare both techniques in the same patient with respect to sensing and pacing characteristics. A total of 16 patients with a mean age of 72 ± 9 years were enrolled; 11 patients had complete atrioventricular block and five had 2nd degree atrioventricular block. Ventricular and atrial OLBI pacing thresholds were significantly lower for the right-sided than for the left-sided approach (0.44 ± 0.09 V vs. 0.53 ± 0.13 V, and 2.01 ± 0.46 V vs. 2.23 ± 0.47 V, respectively). No differences were found in R- and P-wave amplitudes. The present study suggests that the right subclavian approach offers substantial benefit with respect to atrial and ventricular OLBI pacing thresholds.

Key Words

Single lead DDD pacing, floating atrial electrodes, overlapping biphasic impulse (OLBI) pacing, pacing threshold, right and left subclavian vein approach

Introduction

Single-lead VDD pacing is an acceptable alternative to conventional DDD pacing in patients with atrioventricular (AV) block and normal sinus node function [1-5]. Due to their inability to pace the atrium, VDD systems are not used in patients with sick sinus syndrome. Recent studies have provided evidence that single-lead DDD pacing using overlapping biphasic pacing (OLBI) in properly selected patients is a suitable alternative to conventional DDD pacing [6,7]. During OLBI pacing, two monophasic pulses with the opposite polarity and the same amplitude and pulse width are simultaneously delivered from each of the ring electrodes in the atrium instead of the pacemaker casing.

The potential advantages of single-lead DDD pacing over conventional two-lead DDD systems are lower device costs, a simpler implantation procedure, and a reduced lead-related complication rate due to the use of one instead of two leads [8]. Despite a significant reduction in the atrial pacing threshold achieved by integrating the OLBI principle into single-lead DDD systems, several studies reported on a still relatively high incidence of atrial capture failure using the free floating atrial electrodes [9-14]. Since the ability to pace the atrium is directly related to the distance from the electrode to the right atrial wall, potential important differences in atrial contact may exist between lead implantation from the right or left subclavian vein.

The aim of this study was to examine the differences in pacing and sensing parameters for single-lead DDD pacing between the right versus left sided subclavian vein approach in the same patient within the setting of a pacemaker implantation.

Materials and Methods

Patients with symptomatic AV conduction abnormalities, an intact sinoatrial function assessed by intravenous atropine, and an indication for AV synchronized pacing were eligible for the study. A single-lead DDD pacing system (Eikos SLD, Biotronik, Germany) and a bipolar single-lead (SL 60/13-BP or SL 60/15-BP, Biotronik) were used in all patients. The study was approved by the Ethics Committee on Human Research at the Free University Medical Center, Amsterdam, the Netherlands. Informed consent was obtained from all patients prior to the procedure. The lead length to use was selected by two implanting physicians according to a standardized protocol [15]. With the aid of the transcutaneous puncture technique, the lead was subsequently introduced in both the left and right subclavian vein in each patient, and positioned in the right ventricular apex under fluoroscopy. The site of the first introduction was randomly chosen. The time needed for lead positioning was measured, including puncture and fluoroscopy time.

Ventricular pacing threshold, pacing impedance and R-wave amplitude were routinely measured using a pacing system analyzer (ERA 300, Biotronik). Minimal amplitude of the unfiltered bipolar atrial electrocardiogram of ≥ 0.3 mV was required for the permanent lead positioning before determining the OLBI pacing threshold. An atrial OLBI threshold of > 3.0 V was considered a failure for implantation, and ≤ 3.0 V threshold was considered acceptable. An OLBI threshold of ≤ 2.0 V was regarded as a good result. Sensing values were averaged over 10 R- or P-waves, and pacing values were averaged over three episodes. The position of the atrial dipole was documented by X-ray.

Statistics

All values are expressed as mean ± standard deviation. Groups were compared using a two-sided paired t-test. A p-value < 0.05 was considered significant.

Results

The baseline characteristics of study patients are shown in Table 1. Five patients had a myocardial infarction more than 6 months before implantation. Eleven patients had 3rd degree AV block and five had Mobitz II 2nd degree AV block. The SL 60/13-BP lead was inserted in nine patients and the SL 60/15-BP lead in seven patients. There were no complications associated with the puncture technique. Table 2 shows all measured results. The right-sided approach led to significantly lower values for the ventricular pacing threshold and the atrial OLBI pacing threshold. No significant difference was found with respect to the bipolar P-wave and R-wave amplitude.

Age (mean ± standard deviation)	72 ± 9 years
Male/female	13/3
Myocardial infarction	5
Coronary artery disease	7
Reason for pacemaker implantation	
AV-block III	11
AV-block II	5
Single-pass lead	
SL 60/13-BP	9
SL 60/15-BP	7

Table 1. Baseline characteristics of study patient.

	Left-sided	Right-sided	p-value
Lead positioning time (min)	15 ± 6	16 ± 7	ns
R-wave amplitude (mV)	14.5 ± 5.1	18.5 ± 5.8	ns
Ventricular threshold (V)	0.53 ± 0.13	0.44 ± 0.09	0.029
P-wave amplitude (mV)	2.03 ± 1.12	1.96 ± 0.96	ns
OLBI threshold (V)	2.23 ± 0.47	2.01 ± 0.46	0.032

Table 2. Implantation results for the left-sided and right-sided subclavian approach (mean ± standard deviation). OLBI = overlapping biphasic pacing. ns = not significant.

Discussion

Single-lead DDD pacing may offer substantial advantages compared to conventional DDD pacing with respect to lower costs and a reduced complication rate related to the absence of an additional lead for the atrium. Brownlee et al. reported on (early or late) complications in 11% of implanted atrial leads as compared to a 2% complication rate with ventricular leads in the same patient group [8]. Connolly et al. observed significantly more complications in physiologic pacing systems requiring two leads (9.0%) than in ventricular pacing systems using one lead (3.8%, p-value < 0.001) in a group of 1474 patients randomly assigned to either pacing mode [16]. Therefore, limiting the number of implanted leads by the use of single-lead (OLBI) DDD pacing systems may substantially reduce the complication rate.

A major limitation of the single-lead (OLBI) DDD pacing remains a relatively high incidence of atrial capture failure, ranging from 19% – 24% [6,7]. Additionally, atrial threshold values are higher than those of conventional atrial leads. In a large series of 250 implantations, Sassara et al. obtained a mean atrial OLBI pacing threshold of 2.6 ± 1.0 V [10]. In contrast to the present study, they found a lower atrial threshold in the group of patients with a left-sided approach as compared to the right-sided approach. Since the study of Sassara et al. was not randomized, groups were not comparable with respect to other variables, which may be accountable for the observed differences in threshold values. In addition, they selected lead length without a standardized procedure. Other studies on single-lead DDD pacing did not address the issue of implantation side [9,11-14].

In the present study, patients served as their own control. Our data demonstrate that a right-sided approach is significantly more favorable for both ventricular and OLBI atrial pacing thresholds, with a 20% reduction in the latter compared with the left-sided approach. This is the first controlled study to investigate which implantation side should be preferred during the implantation of a single-lead VDD (or, in the future, single-lead DDD) pacemaker. However, atrial pacing thresholds are still considerably higher as compared to conventional DDD pacing, indicating the need for further modification of this pacing technique.

Conclusion

For single-lead DDD pacing with the OLBI technique, the right-sided subclavian approach should be used. It was superior to the left-sided approach with respect to atrial and ventricular pacing thresholds.

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Contact
C.M.C. van Campen, MD
Department of Cardiology
Academic Hospital VU
De Boelelaan 1117
NL-1081 HV Amsterdam
The Netherlands
Phone: +31 20 44 422 44
Fax: +31 20 44 424 46
E-mail: cardiol@azvu.nl