Does the OLBI™ Configuration Solve the Problem of Exit Block During Permanent CS Pacing ?

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Summary

The OLBI™ (OverLapping BIphasic) pacing system was constructed for RA (right atrium) wall pacing using floating ring electrodes of a single lead, and proved to be successful in several acute and chronic investigations. Permanent CS pacing brings significant risk of high pacing threshold or ever exit block problems. We evaluated the OLBI™ system for permanent CS pacing. The results of the acute study in 39 patients showed significant decrease of mean pacing threshold from 2.8 to 1.3 V when BP pacing using ERA 300B was switched to OLBI™ stimulation; this effect was not accompanied with increase of current drain on pacing at threshold values (4.6 and 4.1 μA, respectively). In 15 patients, Biotronik EIKOS SLD pacemakers, the atrial channel of which were connected with standard BP CS leads, were implanted. Telemetry performed 1 week, 1, 2 and 3 months after implantation showed significantly lower pacing threshold with OLBI™ CS pacing (1.9, 1.8, 2.0, 2.0 V) than with UP program CS pacing (4.1, 4.6, 3.9, 4.3 V, respectively). In a control group of 234 patients with standard BP CS leads and typical pacemakers, the average results of BP pacing thresholds were: 3.8, 3.8, 3.5, 3.4 V, respectively. In the OLBI™ CS paced patient group there was no pacing problem; temporary maximal energy pacing did not induce either ventricular or diaphragm pacing. Energy consumption was slightly higher than on routine BP pacing. The results implied the utilization of the OLBI™ system for permanent CS pacing.

Key Words

coranary sinus, biatrial pacing, OLBI™ configuration, atrial arrhythmia

Introduction

Coronary sinus (CS) is the oldest [1] and important, difficult, but still promising siteof left atrial (LA) sensing/pacing [1-6]. LA sensing enables precise and safe programming of optimal AV delay, without the risk of pacemaker syndrome in DDD pacing systems [7]. Inter/intra-atrial conduction disturbances are the frequent reason of recurrent atrial arrhythmias [3, 9, 10]. On the other hand, in the same patients, right atrium appendage (RAA) lead localization makes AV programming difficult - long AV delay leads to higher risk of PMT and limitation of the upper tracking rate (UTR) [7, 8]. CS pacing is the basic approach for atrial re-synchronizing pacing modes (biatrial pacing), too [3, 11, 12]. CS pacing brings higher risk of lead dislocation (approx. 10%) and significantly higher pacing threshold and energy consumption [13-14] when compared to routine RAA pacing. CS lead exit block (transient or constant) makes LA pacing impossible in 2-5% of patients. High energy UP pacing from the distal part of CS, leads to secondary ventricular pacing or left diaphragm pacing in 5% and 1%, respectively. The OLBI™ (OverLapping BIphasic) stimulation system allows RA pacing using two atrial floating rings of a single lead, based on deeper penetration of the impulse compared to conventional pulse configurations. [15-17]

The aim of the study was the evaluation of the OLBI™ system used for the CS approach with regard to effectiveness, values of pacing thresholds (in comparison with UP and BP pacing), the risk of secondary left ventricle pacing and left diaphragm pacing at acute or chronic examinations.

Examined acute parameters of pacing	Temporary pacing program	UP distal	UP proximal	BP	OLBI
Threshold of pacing (V)	No. of patients	39	39	39	39
	Range	0.4-10.0	0.6-4.4	0.6-7.6	0.2-3.7
	Mean	**3.9**	**2.1**	**2.8**	**1.3**
	SD	2.6	1.0	1.6	0.8
Resistance (Ω)	No. of patients	39	39	39	39
	Range	270-1210	238-672	370-1154	380-1292
	Mean	**531**	**346**	**601**	**606**
	SD	198	111	178	202
Total current drain (while pacing at threshold values) (μA)	No. of patients	34	33	34	37
	Range	1.8-16.8	2.1-15.6	1.5-10.2	0.3-9.2
	Mean	**7.3**	**6.5**	**4.6**	**4.1**
	SD	4.0	3.2	2.1	2.4

Tab.1: Results of atrial temporary pacing from coronary sinus (CS)

Acute examinations

In 39 patients (m:16, f:23), mean age 66.4 years (from 52 to 74), standard BP Biotronik leads were implanted in the middle part of CS. Intraoperative pacing and sensing parameters were measured with Biotronik's ERA 300B external threshold analyzer. Sensing parameters: P wave amplitude, P slew rate and pacing parameters: pacing threshold, resistance, current drain (during pacing at threshold values) were measured for UP, BP, and OLBI™ program configuration. The results are shown in Tab.1.

Chonic examinations

In 15 patients, Biotronik EIKOS SLD pacemakers were implanted. The atrial channel was connected with standard BP CS leads that were introduced in the CS. Telemetry was performed during follow up investigations. The data in Tab.2 shows good sensing values (P-wave amplitude over 2.5 mV). Pacing thresholds were significantly lower with the OLBI™ system in comparison with standard UP pacing (more than 100% difference). Average threshold with the OLBI™ pacing program was lower; in about 50% of the patients the thresh-old was lower than the minimal programmed pacemaker (EIKOS SLD) atrial stimulation amplitude (1.5V). Telemetry performed 1 week, 1, 2 and 3 months after implantation showed significantly lower pacing threshold with OLBI™ CS pacing (1.9, 1.8, 2.0, 2.0 V) than with the UP program CS pacing (4.1, 4.6, 3.9, 4.3 V, respectively).

In a control group of 234 patients with standard leads and typical pacemakers, average results of BP pacing threshold were: 3.8, 3.8, 3.5, 3.4 V, respectively. Atrial pacing problems observed in 15 patients with EIKOS SLD pacemakers were compared with a group of 236 patients with standard BP Biotronik leads in CS paced with typical (single or dual chamber) pacemakers (Tab.3 and 4).

During observation there was no problem with atrial pacing in any patient of the EIKOS SLD group. No patient needed maximal pacing energy in A channel (4.8 V; 0,75 ms). The temporary OLBI™ stimulation with maximal energy did not cause ventricular and left diaphragm pacing.

The result of comparison of permanent typical BP and OLBI™ pacing mode imply the usefulness of the OLBI™ pacing system for permanent CS pacing.

Electrophysiological effects of UP and OLBI™ CS pacing

On routine control of patients after pacemaker implantation we found some differences in S-Q (pacemaker spike - Q wave) interval and paced P(II) wave width at UP and OLBI™ CS pacing; the results are shown in Tab. 5. Furthermore Figure 1 and 2 present two cases demonstrating the mentioned findings.

UP CS pacing was combined with longer SQ interval and longer P(II) wave duration than on sinus rhythm. OLBI™ CS pacing provided shorter SQ intervals without significant increase paced P(II) wave duration. Slightly more synchronous atrial activation is yielded

Analyzed Parameters		Acute	Control Examination				
		ERA 300B	Telemetry Biotronik PMS 1000				
		On operation	immed. after OP	1 week	1 month	2 months	3 months
P Amplitude on BP Sensing	No. Of pts.	15	15	10	8	5	3
	Average	**3.2**	**2.9**	**2.8**	**2.7**	**3.9**	**3.3**
	SD	1.7	1.6	1.4	1.8	1.7	1.7
UP Pacing Threshold	No. Of pts.	12	15	12	9	6	5
	Average	**4.1**	**4.4**	**4.1**	**4.6**	**3.9**	**4.3**
	SD	2.8	2.9	2.4	2.0	2.0	1.8
	Median	3.5	4.4	3.8	4.8	4.0	4.8
OLBI Pacing Threshold	No. Of pts.	12	15	12	10	6	5
	Average	**2.7**	**1.7**	**1.9**	**1.8**	**2.0**	**2.3**
	SD	1.2	0.3	0.6	0.4	0.8	0.8
	Median	2.5	1.5	1.6	1.6	1.6	2.2
Total current drain with OLBI pacing	No. Of pts.	-	7	7	10	4	5
	Average	-	**67.8**	**70.0**	**69.1**	**64.0**	**63.8**
	SD	-	15.5	15.1	17.1	10.9	9.6
	Median	-	72	70	66	66	65
No. of pts. with pacing threshold < 1.5 V	UP pacing	3/12 (25%)	4/15 (27%)	3/12 (25%)	0/9 (0%)	1/6 (17%)	0/5 (0%)
	OLBI pacing	2/12 (16%)	9/15 (60%)	6/12 (50%)	5/10 (50%)	3/6 (50%)	1/5 (20%)

Tab.2: Results of permanent coronary sinus OLBI™ pacing, comparison with UP-program.

with OLBI™ CS pacing, while the obtained results are similar to our earlier observations on high energy CS permanent pacing.

EIKOS SLD as biatrial pacemaker

8 of 15 described patients with chronotropic incompetence, recurrent atrial arrhythmias and without AV conduction disturbances received a biatrial pacing system (EIKOS SLD). CS BP leads were connected with atrial and RAA UP leads - using the ventricular channel of the pacemaker. DDD pacing (80-85 bpm) with AV delay 15 ms was chosen as a standard program.
There were no pacing/sensing problems in any patient

Compared CS paced groups	Pacing program	Pacing problems				
		No Problems	Exit block re-operation	Dislocation	Diaphragm Pacing	Left ventr. pacing
EIKOS SLD	OLBI permanent pacing	15/15 100%	0/15 0%	0/15 0%	0/15 0%	0/15 0%
Other single or dual chamber pacemakers	BP permanent pacing	209/236 88.5%	4/236 1.7%	31/236 13.1%	0/236 0%	3/236 1.3%
	UP temporary pacing				1/226 0.4%	7/226 3.1%

Tab. 3. Permanent CS atrial pacing problems - a comparison of groups of 15 patients paced with OLBI system and 236 patients with standard pacemakers and BP atrial lead in CS.

Compared CS paced groups	Pacing program	Pacing threshold after 2 months	
EIKOS SLD	OLBI CS Permanent Pacing	No. of pts.	6
		Mean	2.03
		SD	0.8
		Median	1.6
Other single or dual Chamber Pacemakers	BP CS Permanent Pacing	No. of pts.	147
		Mean	3.47
		SD	1.7
		Median	3.3

Tab. 4. Permanent CS atrial pacing conditions - a comparison of groups of patients paced with OLBI™ system and patients with standard pacemakers and atrial BP lead in CS.

Analyzed parameters		Sinus rhythm	UP pacing	OLBI pacing
P(S) - Q duration	No. of pts.	13	14	14
	Mean	189.2	213.6	178.9
	SD	47	39.1	26.6
	Median	180	220	185
P(II) wave duration	No. of pts.	14	15	15
	Mean	138.9	168.3	146
	SD	25.3	32.8	34
	Median	140	160	140

Tab. 5. Electrophysiological effects of permanent OLBI™ CS pacing.

and antiarrhythmic effects were observed to be excellent in 2, good (significant depression of arrhythmia recurrence) in 4 and moderate (slight antiarrhythmic success) in other 2 patients.

During Holter monitoring and repeated IEGM recordings we observed an excellent re-synchronization during paced or permanent left atrial beats. There was no re-synchronizing pacing in case of spontaneous sinus rhythm or premature right atrial beats.

Preliminary observation showed that this biatrial pacing system is useful mainly in patients with known left atrial arrhythmias. In figure 3 and 4 respective applications in two cases are presented.

We observed an excellent clinical benefit of permanent BiA pacing. Spontaneous sinus rhythm was never observed (100% pacing beats in pacemaker holter) and permanent BiA pacing 85 bpm decreased AFL recurrences from 1 per week to 1 per 3 months.

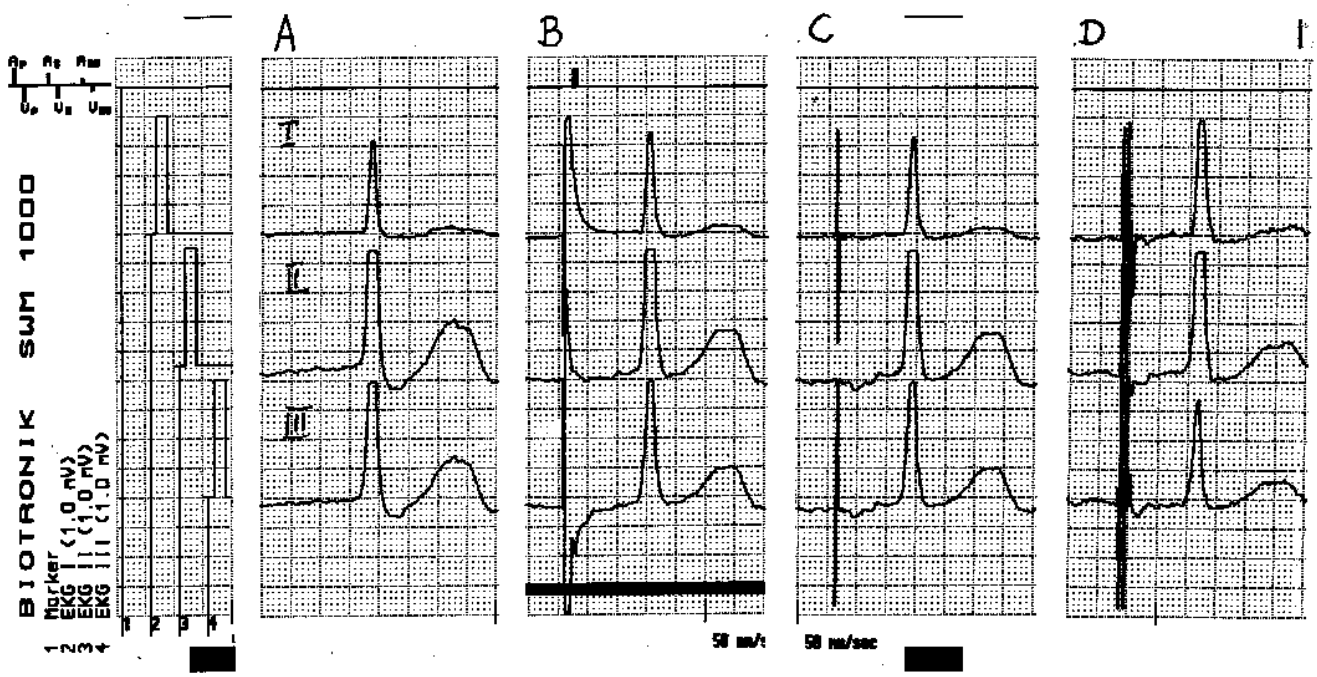


Fig 1. Male patient, aged 64, with severe sinus node chronotropic incompetence (stable nodal rhythm 46/min), frequent recurrence of atrial flagellation and without A-V conduction disturbances. Biatrial pacing system is implanted. EIKOS SLD pacemaker is used. CS BP lead is connected to atrial and RAA UP lead to ventricular channel. A: low AV nodal rhythm. B: CS UP pacing program; SQ 240 ms, P(II) duration 200 ms. C: CS OLBI™ pacing program; SQ 200 ms, P(II) duration 140 ms. D: BiA pacing - DDD program (RA UP pacing, CS OLBI™ pacing with AV delay 15 ms); SQ 200 ms, P(II) duration 120 ms. Patient is treated with low doses of amiodarone and remains arrhythmia free for two month of follow-up. Shorter P(II) duration can suggest slight synchronizing effect of CS OLBI™ pacing in comparison to UP CS pacing.

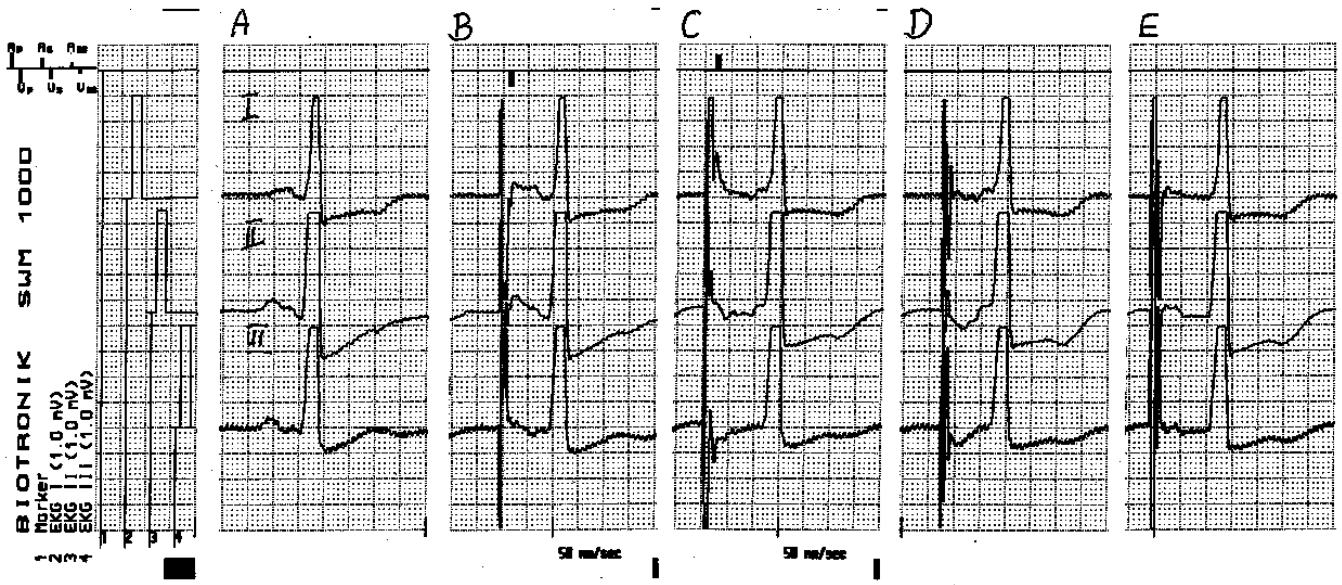
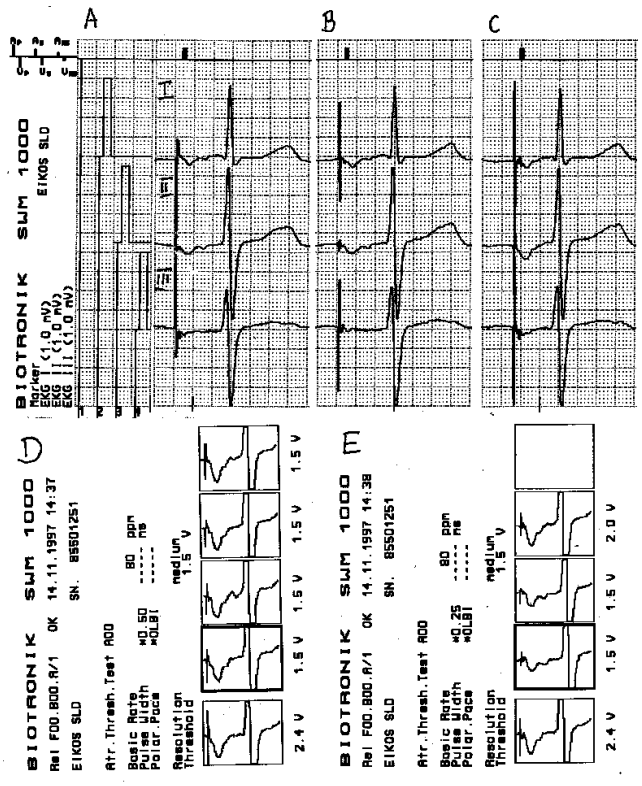


Fig. 2. Female patient, aged 76 with inter-atrial conduction disturbance and frequent AFL recurrences. BiA pacing system is implanted with technical details as described in fig. 1. A: sinus rhythm; PQ(II) 160 ms, P(II) duration 160 ms. B: RAA UP pacing (VDD temporary program of EIKOS SLD pacemaker); SQ 180 ms, P(II) duration 160 ms. C: CS distal UP pacing; SQ 180 ms, P(II) duration 190 ms. D: CS OLBI™pacing; SQ 180 ms, P(II) duration 140 ms. E: BiA (RAA UP, and CS OLBI™pacing; SQ 220 ms, P(II) duration 100 ms. Patient is treated with propafenon and frequency of AFL decreased from 2 recurrences per week to 1 per month.



Discussion

Initially the OLBI™ system was constructed for RA wall pacing using a typical VDD lead. Many studies reported effective atrial pacing in most of the patients due to deep impulse penetration; pacing thresholds were 1.8-4.0 V. Permanent CS pacing is connected

Fig 3. Female patient, aged 56 with BRT syndrome (sinus bradycardia and frequent recurrences AFL), inter-atrial block and low (95/min) Wenckebach point. Dual chamber pacing system is implanted: pacemaker EIKOS SLD, atrial BP standard lead in CS connected to atrial channel and UP ventricular lead connected to ventricular channel of the pacemaker. A: UP CS pacing; SQ 240 ms, P(II) duration 160 ms. B: OLBI CS pacing with about threshold amplitude values; SQ 250 ms, P(II) duration 160 ms. C: OLBI™ CS pacing with the amplitude equal to 200% of threshold value; SQ 180 ms, P(II) duration 150 ms. D: threshold test with 0.5 ms impulse duration; slight differences in the shape and duration of the P wave are observed if pacing amplitude was lower than 2.4 V. E: threshold test with 0.25 ms of impulse duration; significant difference in P wave morphology and it's duration is found if very low energy was applied. Above findings suggest differences in the front of the atrial depolarization during OLBI™CS pacing in comparison to UP CS pacing (larger area of atrial wall excitation?, bifocal LA wall pacing?).

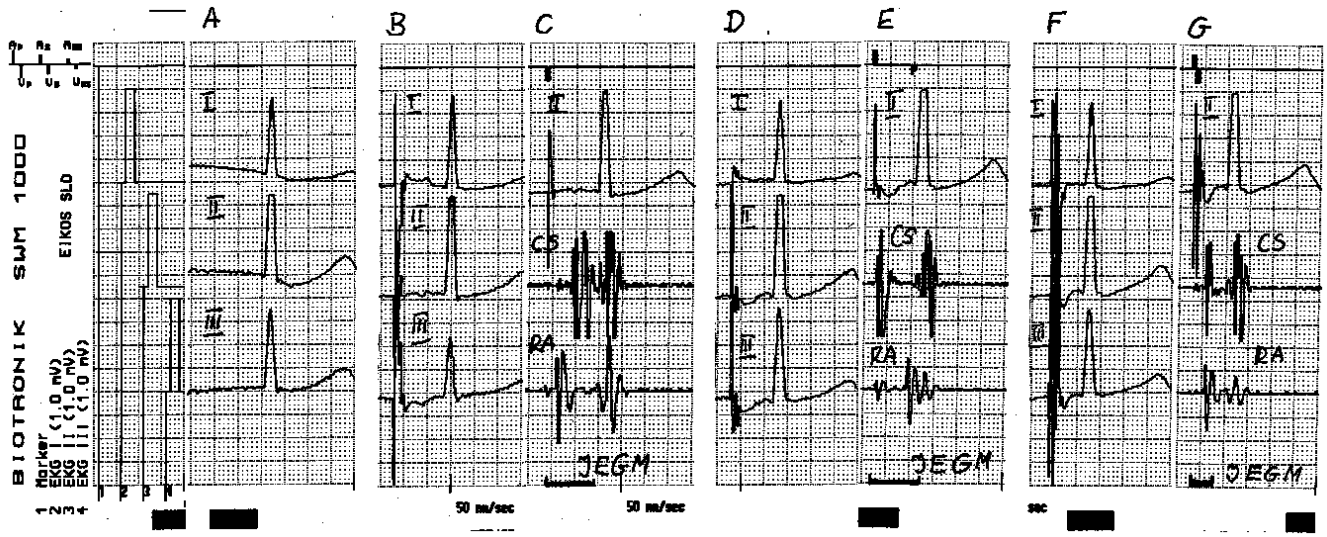


Fig. 4. Female patient, aged 69, recurrences AFL (after several hours usually degenerating to AF), inter-atrial block, severe chronotropic incompetence, no AV conduction disturbances. Patient is given BiA system with Eikos SLD pacemaker. BP CS lead placed in distal position connected to atrial port and UP RAA lead introduced to ventricular channel of the pacemaker. A: nodal rhythm. B and C: UP RAA pacing (VDD temporary program); SQ 200 ms, P(II) duration 160 ms. IEGM: significant delay of left atrial activation is shown. The distance between S and the onset of A wave in opposite atrium 100 ms (S-A), the distance between the S and the termination of A in opposite atrium - total atrial activation time (TAAT) 200 ms. D and E: CS OLBI™ pacing (DDD with long AV program); SQ 160 ms, P(II) duration 140 ms. IEGM: S-A 140 ms, TAAT 220 ms. There is no correlation between P(II) and TAAT, the latter seems to be more valuable parameter of atrial activation. Distal location of CS lead disabled re-synchronizing effect of OLBI™ CS pacing. E and F: BiA pacing (permanent program - DDD with 15 ms AV delay); SQ 125 ms, P(II) duration 120 ms, TAAT 90 ms.

with the risk of high pacing threshold or exit block [13-14]; till now nobody tried to use the OLBI™ system for CS pacing.

In the early 70's Moss [1][2][14] and Greenberg [13] reported some problems with permanent CS pacing; about 10% of this patients needed over-standard high energy parameters. The similar problems with high pacing thresholds were reported by Daubert's team in many abstracts in 1990-1995 [3][10]. Our continuous observation in growing group up to 240 patients high pacing thresholds (4.8 V - 7.2 V, 1 ms) appeared in about 25% of patients [5][6], but reposition of CS electrode due to exit block was necessary in only 2% of patients. Very promising acute and chronic results of CS pacing with OLBI™ system, presented above, allow to hope that the OLBI™ system connected with BP CS leads can help to solve the problem of exit block and risk of unsuccessful pacing in patients paced from CS.

Conclusions

1. CS OLBI™ pacing in acute experiment allows to decrease pacing thresholds substantially.

2. Permanent CS pacing with the OLBI™ system helps to avoid CS exit block and high pacing threshold problems, without risk of left ventricle or diaphragm pacing.

Reference

[1] Moss A, Rivers R, Griffith L, et al. Transvenous Left Atrial Pacing for the Control of Recurrent Ventricular Fibrillation. The New Engl. J. of Medicine. 1968; 278: 928-931.

[2] Moss A, Rivers R. Atrial Pacing from the Coronary Vein. Ten-Year Experience in 50 Patients with Implanted Pervenous Pacemakers. Circulation. 1978; 57: 103-106.

[3] Daubert C, Gras D, Berder V, et al. Resynchronisation Atriale Permanente par la Stimulation Biatriale Synchrone pur le Traitament Práventif du Flutter Auriculaire Associe a un Bloc Interauriculaire de Haut Degré. Arch. Mal. Coeur. 1994; 87: 1535-1546.

[4] Daubert C, Mabo P, Bazin P, et al. Feasibility and Safety of Permanent Left Atrial Pacing via the Coronary Sinus Using „J"-Shaped Leads. PACE. 1993; 16: 1146 (abstr.).

[5] Kutarski A, Poleszak K, Koziara D, et al. Left Atrial Pacing - first Experience and new Insights. Cardiostim Transmediterraneen. Rabat, Marocco. 10-12 February 1997: 52 (abstr.).

[6] Kutarski A, Poleszak K, Koziara D, et al. Left Atrial Pacing - First Experience and new Insights. Cardiostimulazione. 1996; 14: 212 (abstr.).

[7] Barold S. Pacemaker Syndrome During Atrial Based Pacing. *In*: A.E. Aubert, H. Ector & Stroobandt. Red. Cardiac pacing and electrophysiology. Kluwer Academic Publishers 1994: 251-267.

[8] Daubert C, Berder V, de Place D, et al. Hemodynamic Benefits of Permanent Atrial Resynchronisation in Patients with Advanced Interatrial Blocks, Paced in DDD Mode. PACE. 1991; 14: 130 (abstr.).

[9] De Luna B, Cladellas M, Oter R, et al. Interatrial Conduction Block and Retrograde Activation of the Left Atrium and Paroxysmal Supraventrcular Tachyarrhythmia. Eur. Heart J. 1998; 9: 1112-1118.

[10] Daubert C, Leclercq C, Pavin D, et al.Biatrial Synchronous Pacing: A New Approach to Prevent Arrhythmias in Patients with Atrial Conduction Block. *In:* Daubert C, Prystowsky E, Ripart A, red. Prevention of tachyarrhythmias with cardiac pacing Futura Publishing Company inc. 1997: 99-119.

[11] Daubert C, Mabo P, Berder V, et al. Arrhythmia Prevention by Permanent Atrial Resynchronisation in Advanced Interatrial Block. Eur. Heart J. 1990; 11: 237 (abstr.).

[12] Kutarski A, Oleszczak K, Koziara D, et al. Permanent Biatrial Pacing - the First Experiences. PACE. 1997; 20: 2308 (abstr.).

[13] Greenberg P, Castellanet M, Messenger J, et al. Coronary Sinus Pacing. Clinical Follow-up. Circulation. 1978; 58: 98-103.

[14] Moss A, Rivers R, Kramer D. Permanent Pervenous Atrial Pacing from the Coronary Vein. Long Term Follow-up. Circulation. 1974; 49: 222-225.

[15] Lucchese F, Schaldach M. Effect of Valsalva Maneuver and Body Position on Atrial Capture Performance Using Single Lead DDD OLBI™ Stimulation. Results of the BRASILEAD project; EUROPACE '97, Athens; p. 357 - 362; 1997.

[16] Del Guidice G, Frabetti L. DDD Pacing Using a Single AV Lead with Atrial Floating Dipole and Overlapping Biphasic Stimulation; EUROPACE '97, Athens; p. 851 - 856; 1997.

[17] Taskiran M., Weiss I., et al. Pacing with Floating Electrodes and Various Pulse Morphologies; Biomedizinische Technik, Vol. 4, Part II; p. 41-46; 1996.