Ventricular Resynchronization by Left Ventricular Stimulation in Patients with Refractory Dilated Cardiomyopathy

S. S. GALVÃO JR, C. M. B. BARCELOS, J. T. M. VASCONCELOS, M. J. G. ARNEZ, K. N. COUCEIRO, L. CAMPOS, E. SBARAINE, M. G. LYRA, F. S. O. SOUZA
Clìnica de Ritmologia Cardíaca do Hospital Beneficência Portuguesa de São Paulo, São Paulo, Brazil

Summary

Left-ventricular pacing has good results in the treatment of dilated cardiomyopathy and congestive heart failure with intraventricular conduction disturbances. We are presenting our results with this technique in 28 patients with refractory dilated cardiomyopathy and congestive heart failure. Left ventricular pacing was achieved by mini-thoracotomy in three patients, and by transvenous approach via the coronary sinus in 25 patients. The mean duration of the QRS complex was 188 ms, with the existence of left bundle branch block in 22 patients and divisional and right branch block in six patients. All patients had been considered candidates for cardiac transplantation. 16 patients were in NYHA class IV and 12 in class III. The ejection fraction on the Doppler echocardiogram varied from 22 % to 46 % (with an average value of 34 % and a standard deviation of 6 %). The pacing mode employed was biventricular triple-chamber in 22 patients and biventricular dual-chamber in five patients; one patient used an implantable cardioverter defibrillator. All the patients were screened for a mean time of 5 months. All but one patient presented with clinical improvement after implantation, and NYHA classification at the end of follow-up increased to class I (nine patients), II (ten patients) and III (six patients). The initial mean ejection fraction rose to 37 % ± 7 %. Two patients had sudden death (3rd and 10th days after surgery, respectively). One patient died due to pulmonary infection on the 5th day after the operation. We concluded that the ventricular resynchronization through biventricular pacing significantly improved the functional classification and the quality of life of all patients studied. The myocardial evaluations done acutely did not accurately reflect the later clinical improvement.

Key Words

Biventricular pacing, coronary sinus lead, congestive heart failure

Introduction

Despite the advances made in the therapeutic arsenal available for the treatment of heart failure, many patients with dilated cardiomyopathy are refractory to this kind of therapy with an unfavorable prognosis and low quality of life. Of all non-pharmacological procedures indicated for this type of patient, cardiac transplantation in spite of its limitations remains the golden standard. Other options, like cardiomyoplasty and the Batista surgery, had presented controversial results.

In the beginning of the 1990s, Hochleitner [1] was the first to propose artificial cardiac pacing (dual-chamber pacemaker with a short AV delay) for the treatment of refractory heart failure, with astonishing acute results. This treatment, however, was largely disappointing in the short-term follow-up [2,3]. In the early 90s, Xiao et al. [4,5], studied the relationship between myocardial function and intraventricular conduction disturbances in patients with dilated cardiomyopathy, and proved that the wider the QRS complex is, the greater the contraction and relaxation time of the fibers will be, thus influencing the myocardial function. The first to achieve ventricular resynchronization using permanent biventricular (BiV) pacing were Bakker et al. [6] with DDD pacemakers and a Y-adapter in the ventricular output; the right ventricle was paced by anodic current using a conventional lead, and the left ventricle was paced by cathodic current via an epimyocardial lead.

During the first half of the 90s, Cazeau et al. [7], with

the use of a quadruple-chamber pacemaker, began the era of left-ventricular (LV) pacing via the coronary sinus. Since then, ventricular resynchronization via BiV pacing has become a highly valuable adjuvant therapy in the treatment of treatment-refractory congestive heart failure (CHF) with dilated cardiomyopathy in patients with intraventricular conduction disturbances [8,9,10].

In this article, we present our experience with this technique in patients with uncompensated dilated cardiomyopathy and CHF, directed to our hospital for evaluation of the possibility of a cardiac transplantation.

Material and Methods

During the period from April 1999 to August 2000, we implanted 27 pacemakers and one implantable cardioverter defibrillator (ICD) with BiV pacing in 28 patients (23 men and 5 women) with dilated cardiomyopathy, intraventricular conduction disturbances, and non-manageable CHF alongside the optimized course treatment.

The patients were between 36 years and 84 years old (average 58.5 years), and were directed to our hospital by cardiologists that were not able to manage the CHF and asked for an evaluation of the possibility of a cardiac transplantation.

All patients had intraventricular conduction disturbances: six had complete right bundle branch block, 16 had left bundle branch block with left axis deviation, and six had the pattern of left bundle block due to exclusive right ventricular (RV) pacing. Twelve patients were in NYHA-class III and 16 were in NYHA-class IV. The QRS width varied from 140 ms to 220 ms, with a mean value of 188 ms (standard deviation (SD) = 18 ms). Six patients had not been discharged from the intensive care unit due to vasoactive drug dependence.

The procedure was proposed only to regain ventricular resynchronization, without any primary indication to reestablish the cardiac rhythm and/or AV synchrony.

The RV pacing was enabled by a conventional endocardial lead in all patients. The LV pacing was achieved using an epicardial lead in the first three cases, and via the coronary sinus in the resulting 26 patients. One patient with an epicardial lead had an increase in the ventricular threshold, and we implanted a new ventricular lead via coronary sinus (see Figure 1). The leads used for LV pacing via the coronary sinus were: Corox CX LV-75 (Biotronik, Germany) in nine patients, and lead 2187 (75 cm; Medtronic, USA) in 16 patients.

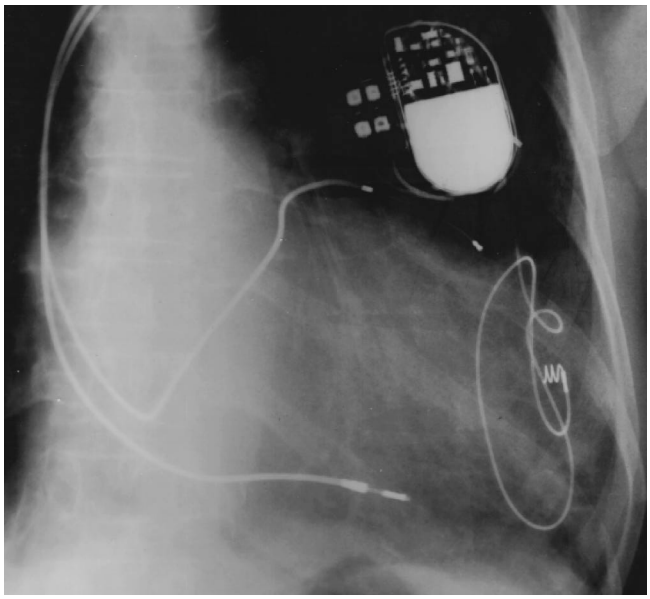

Figure 1. Right anterior oblique radiography of our first patient undergoing BiV pacing for CHF treatment. Observe the epicardial lead abandoned due to threshold increase 6 months after implant. The ventricular resynchronization was regained right after the implantation of a coronary sinus lead on the side wall of the left ventricle. The right ventricle was implanted endocardially, on the infero-lateral wall of the right ventricle.

We used a single-chamber pacemaker with a Y-adapter in one patient, and 22 dual-chamber pacemakers, 18 of which had a Y-adapter in the ventricular channel. In four cases, the atrial channel of the pacemaker was connected to the first ventricle to be activated, and the ventricular channel to the other activated ventricle. The AV delay was programmed to the shortest value, as close as possible to 0 ms. Four cases used special pacemakers with three channels (an atrial channel and a double ventricular output). One patient with atrial flutter, inadequate ventricular response and severe ventricular arrhythmia, received an ICD, with anti-brady, BiV pacing function (see Figure 2).

The etiologies of dilated cardiomyopathy were: ischemia (n = 15), Chagas' disease (n = 5), alcoholism (n = 2), hypertension (n = 1) and idiopathic (n = 5).

The patients were evaluated clinically and through complementary exams before implantation, 10 days,

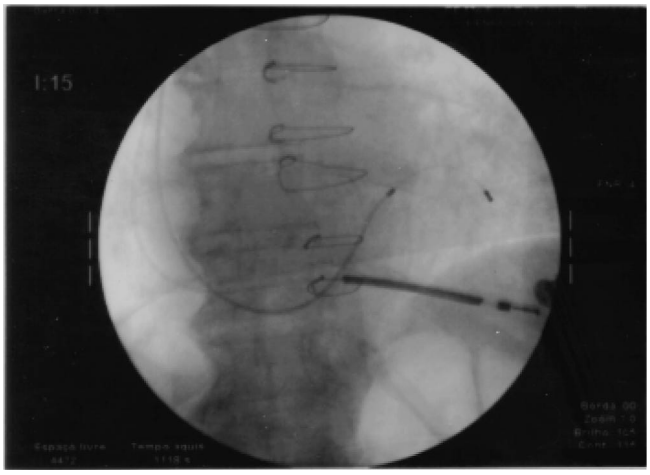

Figure 2. Posterior-anterior radiography of a patient with an ICD, implanted due to dilated cardiomyopathy, atrial fibrillation, low ventricular response, and malignant ventricular arrhythmia. Observe the ICD lead positioned on the infero-apical right ventricular wall, and the coronary sinus lead positioned on the side wall of the left ventricle.

and every 3 months after the implantation. a 6-minute walk test was performed before and after the procedure in order to assess the achieved improvement. Fourteen patients were not subjected to the test before the implantation: eight patients because of some limitation and six because of faults in the protocol compliance.

The ejection fraction (EF) evaluated by Doppler echocardiography was performed before and after the procedure in all patients. It varied from 22 % to 46 % (mean value = 34 %, SD = 6 %). The myocardial scintigraphy was performed before the procedure in 18 patients, with the EF varying from 8 % to 35 % (mean = 20 %, SD = 8 %), and in seven patients 90 days after the procedure, with the mean value changed to 22 % (13 % to 42 %) with an SD of 9 %.

Results

Table 1 shows the mean QRS duration, EF (measured by Doppler echocardiogram and myocardial scintigraphy), NYHA-class before and after surgery.

All patients except one experienced improvement in functional classification. The majority of the 16 patients from class IV before surgery, moved up to classes II and I (n = 9). Three patients who were in class IV before surgery received cardiac transplantation 5 and 6 months after procedure.

Three deaths occurred: two sudden cases on 3rd and 10th days after surgery and one case due to pulmonary infection 5 days after the procedure.

In one case, a dislodgement of the coronary sinus lead occurred. The solution was the use of another lead with a special fixation mechanism. One patient was presented with a pocket infection, solved by the explantation of the whole triple-chamber system.

The EF measured by Doppler echocardiogram had a mean value of 34% (SD = 6 %) before procedure and it improved to 37 % (SD = 7 %) 10 days after the implantation. When the EF was measured in 17 patients 90 days after the procedure, the mean value changed to 43 % (SD = 8 %). The EF measured by myocardial scintigraphy had a mean value of 20 % (SD = 8 %) before surgery in 18 patients. It changed to 22 % (SD = 7 %) in 17 patients 1 week after the procedure and to 22 % (SD = 9 %) 3 months after the procedure in seven patients.

The operation was successful for all attempts to implant the lead into the coronary sinus: six in the anterior wall, 16 in the lateral wall and four in the posterior wall. The BiV and RV endocavitary potential, and the intra- and postoperative pacing thresholds are presented in Table 2. In one case, the coronary sinus lead caused phrenic stimulation (with consequent diaphragmatic stimulation). It impeded the LV pacing using the coronary sinus. In two cases, both of which involved the use of epicardial leads, an increase in the LV pacing threshold occurred. One of these cases occurred right before a cardiac transplant, and, in the other case, the problem was corrected with the implantation of a coronary sinus lead (see Figure 1).

Discussion

Artificial cardiac pacing seems to enter a new era, in which the objective of this procedure is not to reestablish the cardiac rhythm in the usual manner, but maintain hemodynamics through the resynchronization of the cardiac chambers. In this sense, the ventricular resynchronization using BiV pacing has good results in the treatment of drug-refractory CHF with dilated cardiomyopathy in patients with intraventricular conduction disturbances.

As our hospital is a center for cardiac transplantations, the majority of our patients suffer from complete myocardial failure and wait for transplantation (patients in the intensive care unit, using parenteral

Pat #	QRS width (ms)		EF (%) measured by Doppler echocardiography			EF (%) measured by myocardial scintigraphy			NYHA-class	
	pre	post	pre	10 days	3 months	pre	10 days	3 months	pre	post
1	180	120	33	35	41	-	-	-	IV	III
2	200	100	45	45	41	-	-	-	IV	II
3	220	120	28	49	40	-	-	-	IV	II
4	163	110	31	35	44	-	-	-	IV	III
5	180	100	32	47	47	39	38	-	III	I
6	200	110	33	38	-	15	15	15	IV	III
7	200	120	28	39	37	19	20	-	III	III
8	180	100	32	49	49	35	35	42	IV	II
9	180	140	-	-	-	-	-	-	III	death
10	160	130	27	21	44	16	18	20	III	I
11	200	145	-	-	-	-	-	-	IV	death
12	200	140	41	39	37	16	16	13	III	I
13	180	150	46	28	69	-	-	-	IV	II
14	180	90	33	31	37	8	-	-	IV	II
15	190	100	44	36	40	16	16	18	III	I
16	160	90	31	32	43	18	18	-	III	I
17	200	100	22	35	29	15	16	-	III	II
18	200	100	35	35	42	21	21	22	III	II
19	200	100	35	44	44	24	24	26	III	I
20	200	110	45	-	-	29	29	-	III	I
21	210	110	30	38	43	17	18	-	IV	I
22	190	90	35	-	-	-	-	-	IV	death
23	212	160	40	31	-	-	16	-	IV	II
24	180	100	30	31	-	25	25	-	IV	I
25	140	90	29	32	-	12	-	-	IV	III
26	160	90	35	34	-	-	23	-	IV	II
27	180	100	33	45	-	21	21	-	IV	III
28	204	116	29	31	-	15	-	-	III	II
Mean	187	112	34	37	43	20	22	22		
SD	18	20	6	7	8	8	7	9		
Median	190	105	33	35	42	18	20	20		

Table 1. Clinical characteristics of the 28 study patients preoperative (pre) and postoperative (post): QRS width, ejection fraction (EF) measured by Doppler echocardiography and myocardial scintigraphy and NYHA-class

vasoactive drugs), or they have very low quality of life, waiting for this procedure.

In our experience, which is in line with the literature, an important acute clinical improvement was observed

Pat #	Endocavitary potential (mV)				Threshold test (V)			
	RV intra	RV post	BiV intra	BiV post	RV intra	RV post	BiV intra	BiV post
1	18.6	9.0	-	-	1.6	6.0	-	-
2	12.0	4.7	-	-	1.3	2.8	-	-
3	4.8	3.0	-	-	1.1	6.0	-	-
4	3.0	3.0	6.0	6.9	1.1	4.0	2.3	6.0
5	3.3	3.6	5.0	6.5	1.3	1,7	2.3	2.6
6	15.0	9.7	19.0	13.7	1.8	1.9	3.1	3.0
7	8.4	7.8	-	-	0.4	1.6	-	-
8	19.4	6.9	14.2	17.9	0.8	0.8	1.2	2.8
9	4.8	14.5	14.3	-	1.0	-	1.7	-
10	-	9.6	20.9	-	0.3	-	1.4	-
11	7.6	-	4.0	-	1.8	-	2.2	-
12	29.7	-	3.0	8.0	0.5	-	0.9	1.5
13	4.9	-	10.7	-	1.4	-	3.9	2.0
14	3.5	-	3.5	8.0	0.5	-	0.9	1.0
15	5.2	21.7	25.0	22.0	1.5	1.0	2.5	3.0
16	6.0	-	6.0	12.4	0.4	-	0.5	3.5
17	8.5	-	10.0	11.2	0.3	-	0.5	2.0
18	7.8	-	9.2	4.0	0.3	-	0.9	1.5
19	9.9	-	20.8	11.2	0.3	-	0.9	1.0
20	13.1	-	8.3	4.0	0.2	-	0.6	2.5
21	19.4	20.5	20.0	19.4	1.2	2.4	2.7	3.3
22	5.0	14.5	12.5	-	0.6	-	1.5	-
23	10.5	-	9.0	11.2	1.4	-	1.4	0.5
24	2.1	-	14.4	12.5	0.6	-	0.8	1.5
25	6.5	-	15.0	11.2	0.5	-	0.6	1.0
26	6.7	-	-	8.0	0.6	-	-	1.5
27	12.9	-	18.0	11.2	0.4	-	0.6	1.0
28	21.0	-	10.0	9.7	0.4	-	0.6	1.0
Mean	10.0	9.9	11.7	11.5	0.9	2.6	1.5	2.1
SD	6.6	6.0	6.0	5.0	0.5	1.9	0.9	1.2
Median	7.8	9.0	10.4	11.2	0.6	1.9	1.0	1.5

Table 2. Intraoperative (intra) and postoperative (post) right ventricular (RV) and biventricular (BiV) endocavitary potential and pacing threshold.

in all patients, with favorable changes in the NYHA functional class after the surgery. The 6-minute walking test was performed 10 days after implantation, and it demonstrated a significant improvement compared to the test that was performed before the surgery. However this improvement was not followed by significant increase in EF indices, measured by Doppler echocardiography and myocardiac scintigraphy, performed 10 and 90 days after surgery.

BiV therapy started using thoracotomy and epicardial leads, and is now accomplished using endocavitary access, making the implantation procedure relatively

simple and under local anesthesia. The development of new leads with special guides to help reach the coronary sinus will further simplify this method.

Recently, dual-site RV pacing was proposed as an alternative option to BiV pacing for ventricular resynchronization [11]. This procedure was tried for the first time in 1997, when Depuis et al. did not see any benefits over RV output pacing [12]. LeHelloco et al. reproduced these results in 1998 [13]. In our opinion, the dual-site RV pacing could bring some ventricular resynchronization benefit, however it will never compare to the complete ventricular resynchronization benefits achieved with the BiV pacing.

Even the patients who achieved astonishing results due to the BiV pacing retained severe myocardial pathology. In patients with intraventricular conduction disturbances, BiV pacing can be a very useful non-pharmacological option, especially due to its minimally invasive characteristic.

Conclusion

Based on this initial experience, it can be concluded that BiV pacing is an excellent non-pharmacological option for the treatment of CHF refractory to the course treatment in patients with dilated cardiomyopathy and intraventricular conduction disturbances.

Larger studies will show how much and for how long patients can benefit from BiV pacing and will help to identify the most suitable candidates for this kind of therapy.

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Contact
Silas dos Santos Galvao Filho, MD
Hospital Beneficencia Portuguesa
Sao Paulo / SP
Brazil
Telephone: +55 11 284 5826
Fax: +55 11 284 5826
E-mail: sdsantos@uol.com.br