

Clinical Evaluation of Combination Therapy for Biventricular Pacing after Cardiac Surgery in Patients with Intractable Heart Failure

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We examined the effectiveness of combination therapy for biventricular pacing after cardiac surgery. We performed biventricular pacing in seven patients until April 2003. The diagnosis of the patients was ischemic cardiomyopathy (ICM) in four patients and dilated cardiomyopathy (DCM) in three patients. The implantation method of biventricular pacing was performed with a myocardial electrode through a median sternotomy. DDD-R and SSI-R were used to perform biventricular pacing. A Y-adaptor was connected to a generator so that the 2 leads could be implanted in both the right ventricles (RV) and left ventricles (LV). The clinical symptoms were New York Heart Association (NYHA) classification of 3.7 ± 0.3 preoperatively and 1.8 ± 0.6 postoperatively, showing a significant improvement ($p < 0.001$). The cardiac index (CI) was 1.9 ± 0.2 L/min/m² preoperatively and 3.0 ± 0.6 L/min/m² postoperatively ($p < 0.05$). The pulmonary capillary wedge pressure (PCWP) was 19.5 ± 2.6 mmHg preoperatively and 13.6 ± 2.0 mmHg postoperatively, showing a significant improvement ($p < 0.05$). The intracardiac potential and threshold values were: left atrium 1.9 ± 1.0 mV, threshold value (PW: 0.45 msec) 2.1 ± 0.6 V, LV 4.9 ± 4.23 mV, threshold value (PW: 0.45 msec) 2.2 ± 1.51 V, and RV 3.6 ± 0.9 V, threshold value (PW: 0.45 msec) 2.0 ± 0.7 V. The LV and RV threshold values were high. The QRS interval improved from 158.4 ± 18.0 msec preoperatively to 110 ± 13.4 msec postoperatively, showing a significant reduction. This combination therapy when compared to the use of the biventricular pacing method used at the current time, does have the risks of cardiac surgery, but the clinical symptoms and hemodynamic performance improvement are great. (*Ann Thorac Cardiovasc Surg* 2005; 11: 408–12)

Key words: severe heart failure, biventricular pacing, cardiac surgery, combination therapy

Introduction

Multisite pacing has recently been available as a new treatment for patients with chronic congestive heart failure. We report the clinical evaluation of our experiences with biventricular pacing after cardiac surgery for chronic congestive heart failure of patients with ischemic cardiomy-

opathy (ICM) and dilated cardiomyopathy (DCM).

Patients and Methods

Seven patients with intractable heart failure underwent biventricular pacing after cardiac surgery between January 2000 and April 2003 at our institution. The ages of the patients were between 42 and 75 years of age, with a mean age of 58.1 ± 9.8 years. There were 3 males and 4 females. The diagnosis of these 7 patients was ICM in 4 patients and DCM in 3 patients. Previous procedures included coronary artery bypass grafting (CABG) in one patient, and an aortic valve replacement (AVR) in one patient. The preoperative New York Heart Association

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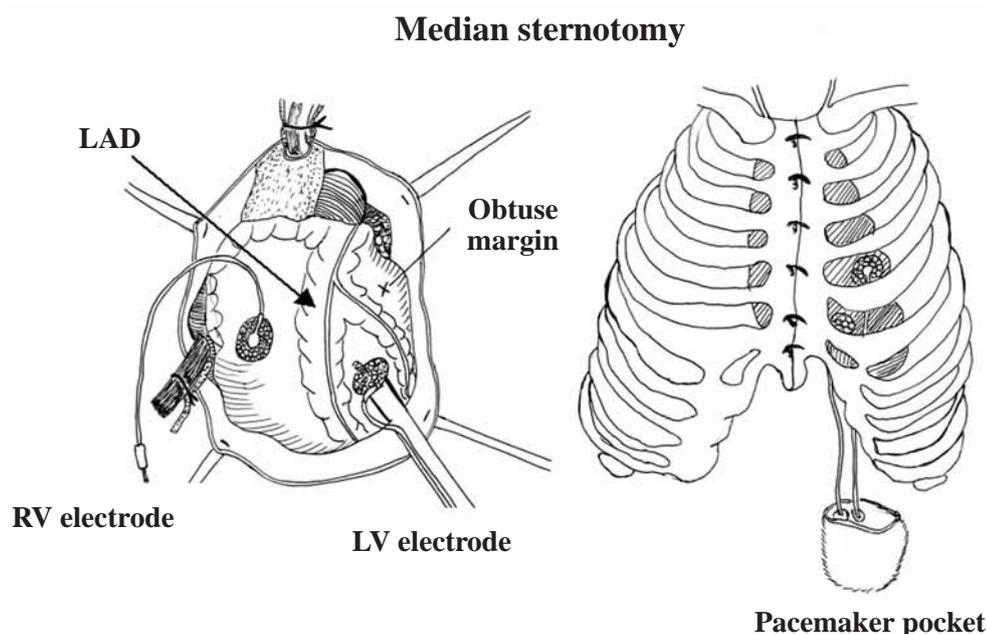


Fig. 1. Operative schema of biventricular pacing.

(NYHA) classification for all patients was NYHA Class IV.

Surgical Procedure

The surgical pacemaker implantation technique for the 7 patients was a median sternotomy and concomitant procedures were performed in all cases (Fig.1). These concomitant procedures included mitral annuloplasty (MAP) and tricuspid annuloplasty (TAP) in two patients, CABG in two patients, Dor's procedure with MAP and TAP in one patient, MAP with maze procedure in one patient, and CABG and MAP in one patient. In these patients the pacemaker lead was placed in the left or right atrial appendage after the patients were weaned from cardiopulmonary bypass. The atrial leads were screw-in type or fishhook-in type and the ventricular leads were also screw-in type. The generator was programmed to DDD-R in six patients who had been in sinus rhythm preoperatively, so atrial kick was expected. One patient had atrial fibrillation preoperatively and the generator was programmed to VVI-R. A pacemaker pocket was created in the left hypochondrium. The pacemaker lead was guided from the pericardium and the generator was implanted (Fig. 2).

We examined the pre and postoperative clinical symptoms, cardiac function, and results for these patients. We

conducted a statistical analysis measuring the numerical value mean±SD and evaluated the difference between the two groups using the paired t-test showing a risk factor of less than 5%, which is significant.

Results

Clinical symptoms

The preoperative clinical symptoms of these patients were classified using the NYHA classification. All patients were in NYHA Class IV preoperatively. Postoperatively all patients were in NYHA I-III, with an average of 1.8±0.6 and showing significant improvement ($p<0.001$).

Cardiac function

Cardiac function was compared pre and post operatively. Preoperatively the average cardiac index (CI) was 1.9±0.2 L/min/m² and postoperatively it was 3.0±0.6 L/min/m², showing a significant improvement ($p<0.005$). Preoperatively the average pulmonary capillary wedge pressure (PCWP) was 19.5±2.6 mmHg and postoperatively it was 13.6±2.0 mmHg, showing significant reduction ($p<0.05$). The average ejection fraction (EF) preoperatively was 33.3±19.8% and postoperatively was 46.5±22.0%. While the ejection fraction did improve, the improvement was not statistically significant.

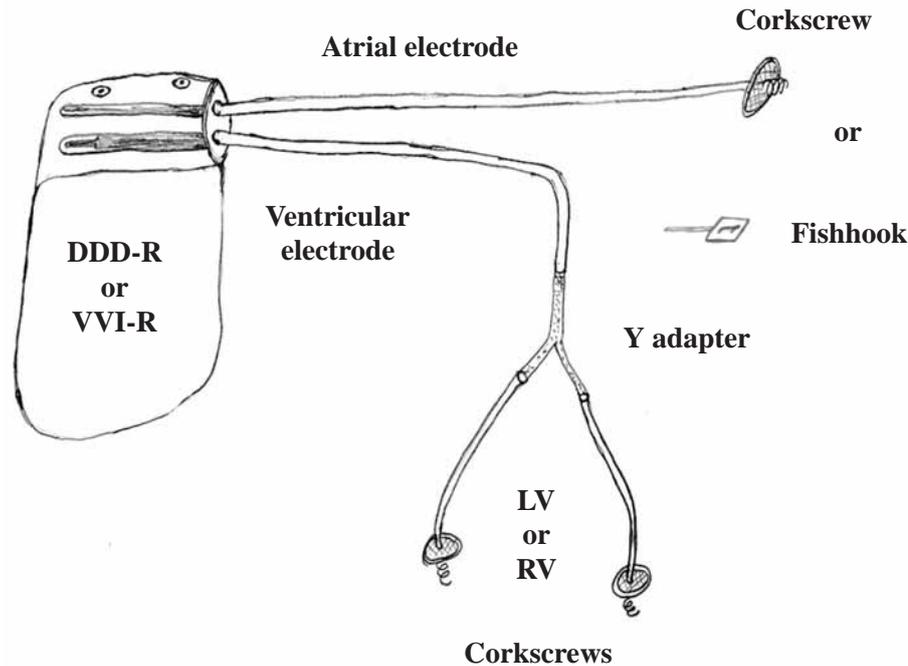


Fig. 2. Schema of pacemaker generator.

The generator was programmed to DDD-R in six patients who were in sinus rhythm preoperatively. One patient had atrial fibrillation preoperatively and the generator was programmed to VVI-R.

Intracardiac ECG

At the time of pacemaker implantation, the intracardiac electrocardiogram (ECG) showed left atrial wave with an average of 1.7 ± 0.8 mV (n=7) and an atrial threshold with an average of 2.0 ± 0.6 was obtained (n=7). The average right ventricular (RV) wave was 3.7 ± 0.6 mV and the average RV threshold was 2.0 ± 0.9 V. The average left ventricular (LV) wave was 5.0 ± 1.3 mV and the average LV threshold was 2.4 ± 0.6 V. The QRS duration pre and post operatively was 158.4 ± 18.0 msec and 110 ± 13.4 respectively, showing a significant reduction ($p < 0.001$).

Surgical results

The surgical results were as follows: The surgical results were survival in seven cases (100%), and no death during hospitalization. Complications were as follows: one case of postoperative ventricular tachycardia and one case of bleeding of the left appendage at the point of lead insertion.

Discussion

Biventricular pacing will offer a new treatment option for patients who are suffering from cardiac conduction

damage, intractable heart failure, and drug intolerance.¹⁻⁴⁾ Patients with complications related to severe cardiac dysfunction due to delayed ventricular conduction and ventricular conduction damage are not rare. Ventricular electric irritability and delayed contraction can contribute to mitral valve regurgitation and subsequently to further decrease in cardiac function. Since the report by Xiao et al.⁵⁾ ventricular conduction delay once followed by LV irritability will often result in what is now called mechanical dyssynchrony. It is reported that when biventricular pacing is performed for inefficient LV contraction, hemodynamics and LV function improve.

A 1996 study to examine the effectiveness of pacing was conducted by Cazeau¹⁾ using patients who were candidates for cardiac transplantation. It was found that the patients with ventricular conduction damage and severe heart failure who were not considered candidates for heart transplantation exhibited significant clinical improvement after biventricular pacing. Since that report, many clinical tests including evaluating symptoms, hemodynamics, exercise endurance, and QOL have been done on patients waiting for heart transplantation, and they showed significant improvement.^{6,7)} This data was used to obtain FDA approval for biventricular pacing as a treatment device

for heart failure in 2001.

The indication standard for biventricular pacing in the U.S. is the MIRACLE test.⁷⁾ Drug intolerant intractable heart failure patients were used. ECG revealed a QRS duration of over 130 msec in cases of left branch conduction blockage or LV conduction damage, however, it is not possible to clearly predict the outcomes. The cases we experienced included four cases of ICM and three cases of DCM. The preoperative NYHA classification was IV for seven cases. The preoperative QRS was 130-200 msec, with an average of 154.8 msec. Although prior to operation diuretics, cardiac glycoside, ACE inhibitors, and inhibitors were used, heart failure occurred again and the patients were hospitalized.

The implantation method used for cases with concomitant procedure was a median sternotomy and after completing surgery but before removing the patient from the cardiopulmonary bypass, the pacemaker was implanted. In these cases the cardiac function was very poor, therefore biventricular pacing was performed with the other concomitant procedures, for example, repair of atrioventricular valve regurgitation (MAP and TAP), LV volume reduction (Dor's procedure) and coronary artery revascularization (CABG) seems to lead to improved myocardial function after cardiac surgery.

To decide the optimal pacing lead position intraoperative ECG is monitored and a position with a good threshold value is selected. The pacing lead is screwed into the ventricular septum between the RV apex and the LV free wall. In Japan there is no insurance coverage for biventricular pacing and there are cases where endocardial electrode leads cannot be inserted in a way that achieves good threshold values. The success rate for positioning the lead through the coronary branches is only 70%.⁸⁾ In the Western world guidewires are used with very good results.⁹⁾ However, because they are not available in Japan, external pacing is performed. Using this method good stimulation threshold values can be achieved when compared to endocardial pacing methods. In our experience of 7 cases the intraoperative intracardiac lead position yielded an average of 1.9 mV for the left atrium and 3.6 mV for the RV, and 4.9 mV for the LV, exhibiting low potentials. The average stimulation threshold value was 2.1V at the left appendage, 2.0 V at the RV, and 2.2 V at the LV. Thus, good biventricular pacing position can be achieved in open heart surgery.

The DDD type pacemaker is used for LV pacing. For atrial and ventricular pacing, the current DDD is good for left appendage and RV pacing, but when biventricular

pacing is done a Y connector is used to consolidate the two leads into one. The lead tip used is either a screw-in type or a fishhook-in type. If the left appendage is far from the operating field, the fishhook-in type is easier to use.

Comparison of the effectiveness of biventricular pacing indicates that the clinical condition is a NYHA classification of IV for all patients preoperatively and an average of 1.8 postoperatively. Swan-Ganz balloon catheters are used to evaluate cardiac performance examining CI and PCWP, showing that both improved significantly. Also the transesophageal echocardiogram allowed a comparison of intraoperative LV wall movement pre and post operatively and is useful to determine LV pacing effectiveness.

The surgical results were survival in seven cases (100%), and no death during hospitalization. Complications included intraoperative attachment of the lead to the left appendage resulting in injury of the appendage and bleeding. Suture managed hemostasis was conducted under direct vision to successfully control bleeding. In one case sustained ventricular tachycardia occurred and anti-arrhythmia medication was administered and it is currently possible to control the patient with medication. The cause of death in 40% of heart failure patients is sudden cardiac death.¹⁰⁾ In the future implantable cardioverter defibrillators (ICD) should be considered. In the Western world ICD testing for biventricular pacing is already being performed.¹¹⁾

The biventricular pacing performed at our institute is not reimbursed by insurance in Japan and we are using currently available pacemakers. When performing biventricular pacing, it is not possible to set the A-V delay to 0 and since high output stimulation is required battery life is questionable and full anesthesia is required leading to higher risks for patients. There are a number of points that require improvement. Given the shortcomings of this procedure, less invasive thoracoscopic methods are being considered.

Some centers are testing current pacemaker technology for pericardial pacing methods as placement of the pacemaker leads between coronary sinus and circumflex can often encounter difficulty. With the current lead locations there is a limit to the threshold value that can be achieved. By performing the procedure under direct vision with the myocardial electrode method it is possible to select a position with a good threshold value. Currently the method selected has to be decided based upon the circumstances of the case. In the future as a non-drug

alternative for severe heart failure, biventricular pacing may become a viable option. We are anticipating fast insurance reimbursement approval for biventricular pacing.

Conclusion

For drug resistant cases of heart failure, biventricular pacing can improve cardiac function and QOL. Currently biventricular pacing therapy is not reimbursed and current pacemaker technology is used to perform the procedure within the current insurance reimbursement scheme. The median sternotomy is performed to place the lead. We believe biventricular pacing is one step closer to becoming a routine procedure for heart failure treatment at our institute.

References

1. Cazeau S, Ritter P, Lazarus A, et al. Multisite pacing for end-stage heart failure: early experience. *Pacing Clin Electrophysiol* 1996; **19**: 1748–57.
2. Auricchio A, Stellbrink C, Block M, et al. Effect of pacing chamber and atrioventricular delay on acute systolic function of paced patients with congestive heart failure. The Pacing Therapies for Congestive Heart Failure Study Group. The Guidant Congestive Heart Failure Research Group. *Circulation* 1999; **99**: 2993–3001.
3. Kerwin WF, Botvinick EH, O'Connell JW, et al. Ventricular contraction abnormalities in dilated cardiomyopathy: effect of biventricular pacing to correct inter-ventricular dyssynchrony. *J Am Coll Cardiol* 2000; **35**: 1221–7.
4. Nelson GS, Berger RD, Fetics BJ, et al. Left ventricular or biventricular pacing improves cardiac function at diminished energy cost in patients with dilated cardiomyopathy and left bundle-branch block. *Circulation* 2000; **102**: 3053–9.
5. Xiao HB, Roy C, Gibson DG, et al. Nature of ventricular activation in patients with dilated cardiomyopathy: evidence for bilateral bundle branch block. *Br Heart J* 1994; **72**: 167–74.
6. Cazeau S, Leclercq C, Lavergne T, et al. Effects of multisite biventricular pacing in patients with heart failure and intraventricular conduction delay. *N Engl J Med* 2001; **344**: 873–80.
7. Abraham WT, Fisher WG, Smith AL, et al. Cardiac resynchronization in chronic heart failure. *N Engl J Med* 2002; **346**: 1845–53.
8. Walker S, Levy TM, Coats AJ, et al. Bi-ventricular pacing in congestive cardiac failure. Current experience and future directions. The Imperial College Cardiac Electrophysiology Group. *Eur Heart J* 2000; **21**: 884–9.
9. Auricchio A, Klein H, Tockman B, et al. Transvenous biventricular pacing for heart failure: can the obstacles be overcome? *Am J Cardiol* 1999; **83**: 136–42D.
10. Linde C, Gadler F, Edner M, et al. Results of atrioventricular synchronous pacing with optimized delay in patients with severe congestive heart failure. *Am J Cardiol* 1995; **75**: 919–23.
11. Bristow MR, Feldman AM, Saxon LA, et al. Heart failure management using implantable devices for ventricular resynchronization: Comparison of Medical Therapy, Pacing, and Defibrillation in Chronic Heart Failure (COMPANION) trial. COMPANION Steering Committee and COMPANION Clinical Investigators. *J Card Fail* 2000; **6**: 276–85.