Efficacy of Cardiac Resynchronization Therapy Performed Concomitantly with Primary Cardiac Surgery

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Cardiac resynchronization therapy (CRT) improves symptoms and cardiac function in patients with heart failure and prolongs QRS duration on an electrocardiogram. However, additional effects of concomitant CRT in patients who undergo cardiac surgery are unclear. We assessed the clinical efficacy of this therapy when it is performed concomitantly with primary cardiac surgery.

METHODS: We evaluated four patients who underwent primary surgery and CRT between February 2002 and December 2003, and compare clinical data with four patients who underwent conventional primary surgery without CRT.

RESULTS: Primary surgeries were CABG (n = 2), aortic valve replacement (n = 1), mitral valve plasty (n = 1) and mitral annular plication (n = 4). After the operation, symptoms associated with congestive heart failure were improved in all patients. The average NYHA class improvement was from 3.3 ± 0.5 before the operation to 1.7 ± 0.6 after the operation. All patients were discharged after surgery. Only one patient needed re-hospitalization for congestive heart failure one month after the operation. The mean QRS duration (190 ± 47.6 ms vs 160 ± 16.3 ms), cardiothoracic ratio (60.7 ± 5.7% vs 58.5 ± 2.9%) and ejection fraction (28.5 ± 8.8% vs 50.0 ± 0.0%) were also improved after surgery.

CONCLUSION: In patients with poor left ventricular function and impaired cardiac conduction, CRT performed concomitantly with primary surgery may improve the post-operative course. Further study on indications for implantation of a CRT device during primary surgery is needed.

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Key words: Cardiac resynchronization therapy, Cardiac surgery, Epicardial lead

Introduction

Since the introduction of angiotensin-converting enzyme (ACE) inhibitors and beta-blockers in the treatment of heart failure due to left ventricle (LV) systolic dysfunction, pharmacological therapy for patients with heart failure has made remarkable progress. However, the prognosis of patients with
severe heart failure remains poor. The benefit of medical treatment is probably short-lived, merely delaying the inevitable progression to heart failure that is refractory to drug treatment.\(^3\) A subset of patients with severe systolic heart failure have a prolonged QRS duration, which several studies have suggested as an independent risk factor for adverse outcome in patients with heart failure due to LV systolic dysfunction.\(^6\) Cardiac resynchronization therapy (CRT), which can coordinate asynchronous motion of the LV and reduce mechanical mitral regurgitation, has been shown to improve symptoms, quality of life, and exercise capacity of patients with severe heart failure.\(^5\) CRT has the possibility to become a useful optional strategy for patients with severe heart failure and prolonged QRS duration. Moreover, the CRT may be beneficial as additional therapy in patients receiving cardiac surgery due to heart failure. The aim of this study was to elucidate the effect of CRT when it is performed concomitantly with primary cardiac surgery.

### Methods

1) Subjects

Four patients with New York Heart Association class III or IV heart failure due to LV systolic dysfunction (ejection fraction < 35% assessed by echocardiography or left ventriculography) and a duration of the QRS interval of more than 120 ms were evaluated.

The characteristics of the patients are summarized in **Table 1**. All patients had shortness of breath and limitation of activities of daily life in spite of optimal medical treatment including diuretics and ACE inhibitors. DDD pacemakers had been implanted for complete AV block in three patients before primary cardiac surgery. Implantation of a pacemaker was planned for another patient who had sick sinus syndrome. All patients underwent primary cardiac surgery, including coronary-aortic bypass graft, aortic valve replacement, mitral valve plasty and mitral annular plication, and also underwent concomitant CRT between February 2002 and December 2003. Control group consisted of four patients (mean age 68.7 ± 8.5 years) with New York Heart Association class III or IV due to LV systolic dysfunction.

<table>
<thead>
<tr>
<th>Case</th>
<th>Age</th>
<th>Diagnosis</th>
<th>Pacemaker implantation before operation</th>
<th>Operation</th>
<th>Operation time (hours)</th>
<th>Hospitalization after operation (days)</th>
</tr>
</thead>
<tbody>
<tr>
<td>1 male</td>
<td>61</td>
<td>OMI (Anterior), SSS, Chronic renal failure on HD</td>
<td>No</td>
<td>CABG (Ao-D1-LAD), MAP</td>
<td>4.5</td>
<td>23</td>
</tr>
<tr>
<td>2 female</td>
<td>60</td>
<td>d-HCM, AR, MR, Complete AV block</td>
<td>DDD</td>
<td>AVR (CM21 mm), MAP</td>
<td>7.5</td>
<td>22</td>
</tr>
<tr>
<td>3 male</td>
<td>68</td>
<td>Unstable AP, OMI, Complete AV block</td>
<td>DDD</td>
<td>Emergent CABG (LITA-LAD, Ao-RCA-LCx) MAP</td>
<td>6</td>
<td>23</td>
</tr>
<tr>
<td>4 female</td>
<td>72</td>
<td>DCM, MR, Complete AV block</td>
<td>DDD</td>
<td>MVP, MAP</td>
<td>5</td>
<td>29</td>
</tr>
</tbody>
</table>

**Table 1** Patient characteristics.

<table>
<thead>
<tr>
<th>Case</th>
<th>Age</th>
<th>Diagnosis</th>
<th>Operation</th>
<th>Operation time (hours)</th>
<th>Hospitalization after operation (days)</th>
</tr>
</thead>
<tbody>
<tr>
<td>1 male</td>
<td>62</td>
<td>OMI (Inferior), MR</td>
<td>CABG MAP</td>
<td>7.3</td>
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<tr>
<td>2 female</td>
<td>78</td>
<td>AS, PH</td>
<td>AVR</td>
<td>6</td>
<td>30</td>
</tr>
<tr>
<td>3 male</td>
<td>61</td>
<td>Old MI (Anterior)</td>
<td>CABG MAP</td>
<td>3.5</td>
<td>20</td>
</tr>
<tr>
<td>4 male</td>
<td>74</td>
<td>Unstable angina</td>
<td>MVP, MAP</td>
<td>3.8</td>
<td>37</td>
</tr>
</tbody>
</table>

**Table 2** Patient characteristics of control group.

\(\text{OMI} = \text{myocardial infarction, HCM = hypertrophic cardiomyopathy, AR = aortic regurgitation, DCM = dilated cardiomyopathy, CABG = coronary-aortic bypass graft, MAP = mitral annular plication, AVR = aortic valve replacement, MVP = mitral valve plasty}\)
dysfunction (ejection fraction < 35% assessed by echocardiography or left ventriculography) who underwent conventional primary surgery without CRT. Primary surgeries were CABG (n = 3), aortic valve replacement (n = 1) and mitral annular plication (n = 1). (Table 2)

2) Implantation of a biventricular pacemaker
In all cases, epicardial leads were used for LV pacing with the lead tip placed in the LV lateral wall. The atrial lead was placed high in the right atrium, and the right ventricular (RV) lead was placed at the apex. In patients who had undergone DDD pacemaker implantation, an intravenous lead for DDD pacing was used for CRT. VIRTUS PLUS II DR 1480 (Guidant, Minnesota, USA) was used in all subjects with LV and RV leads connected to the ventricular port of the pacemaker by a 2-in-1 connector. Optimal AV delay was determined individually after the operation by coordination of LV wall motion and LV inflow pattern on an echocardiogram.

3) Follow-up
At baseline (before the primary operation), soon after the primary operation and at the end of the follow-up period, patients were evaluated according to NYHA classification, need for hospitalization, and result of 12-lead electrocardiography, chest radiography and echocardiography. LV dimensions were measured by M-mode echocardiography in the parasternal long axis view. LV ejection fraction was quantified by Simpson’s method or by left ventriculography.

Results
1) Initial clinical courses
The implantation of the device was successful and scheduled primary operations of all case were performed uneventfully. There was no complication related to implantation of CRT devices. Operation time was a little longer than that of conventional primary operation without CRT (Table 1). (Mean operation time: 5.7 hours vs 5.2 hours).

Postoperative course of patients 1, 2 and 3 were uneventful. Only one patient (patient 4) suffered from persistent congestive heart failure due to sensing failure of the atrial lead. After adjustment of the pacemaker program, the patient’s congestive heart failure improved and the postoperative course after that was satisfactory. After the operation, symptoms of all patients associated with congestive heart failure improved. The average of NYHA class improved from $3.3 \pm 0.5$ before the operation to $1.7 \pm 0.6$ after the operation (Figure 1). Mean hospitalization period after operation was shorter than that of control group (24.3 days vs 28.8 days). All patients were discharged after surgery. However, one patient (patient 1) needed re-hospitalization for congestive heart failure one month after the operation because of worsening of mitral regurgitation. The other three patients did not need hospitalization after discharge and are doing well without special limitations on their daily life.

2) Follow-up
CRT reduced the mean QRS duration from $190 \pm 47.6$ ms before operation to $160 \pm 16.3$ ms after the operation (Figure 2). However, one patient (patient 1) showed no significant change in QRS duration after the operation.

The cardiothoracic ratio (CTR) decreased slightly during a period of 15.2 months after the operation ($60.7 \pm 5.7\%$ vs $58.5 \pm 2.9\%$). CTR in patient 1, who had recurrence of congestive heart failure after discharge, was higher than that before the operation. Results of echocardiographic study are shown in

![Figure 1](NYHA Class) NYHA classifications before and after surgery. NYHA classification improved in all patients after the operation.

![Figure 2](QRS Duration) QRS durations before and after surgery. QRS duration improved in all but one of the patients.
Table 3. The postoperative ejection fraction (EF) had a tendency to improve after the operation (28.5 ± 8.8% vs 50.0 ± 0.0%), and LV wall motion, especially that of the ventricular septum and lateral wall, was more symmetrical than that before the operation in all cases.

The average of end-diastolic dimension of LV also had a tendency to improve, from 60.5 ± 12.8 mm to 55.0 ± 12.2 mm.

Discussion

Both CRT and primary surgery are shown to improve symptoms and cardiac function in patients with heart failure. The distinctive point of this study was to elucidate the effect of CRT and primary cardiac surgery when they are performed simultaneously. In this study, the addition of CRT improved heart failure status and LV systolic function.

The mechanisms by which CRT improves mechanical LV function in patients with asynchronous wall motion are not completely understood. Electrical resynchronization can reduce mechanical interventricular dyssynchrony between the right and the left ventricles and intraventricular dyssynchrony within the left ventricle. Minimizing intraventricular dyssynchrony has been shown to improve global EF function. CRT has been shown to increase LV filling time, decrease septal dyskinesis and reduce mitral regurgitation, thus improving hemodynamics.1) Many studies have shown that both CRT and LV pacing may reduce the degree of asynchronous wall motion of the LV in patients with intraventricular conduction delay. CRT has also been shown to increase systolic blood pressure and reduce PCWP and MR.

A recent randomized trial showed that CRT significantly improves exercise tolerance and quality of life.1,2) Moreover, CRT reduced measures of morbidity and mortality in several studies.3) CRT has become a useful strategy for patients with severe LV systolic dysfunction and CLBBB.

It is possible that CRT supports the postoperative course of patients who have undergone cardiac surgery and improves quality of life and reduces mortality rate. CRT probably has less potential to improve symptoms of heart failure than other primary surgery modalities because it is not a therapy to promote contractibility but to coordinate asynchronous wall motion. The postoperative course of patients is therefore thought to be influenced much more by the primary surgery than by CRT. However, for patients with severe LV systolic dysfunction, a small hemodynamic change may have a big influence on their symptoms. Hemodynamic change induced by CRT, even if it is not so great, can improve the postoperative course of patients with heart failure. Therefore, concomitant CRT should be considered as an additional therapy for patients with LV systolic dysfunction who are scheduled to undergo primary surgery.

Conclusion

CRT performed concomitantly with primary surgery may improve the postoperative course of patients with poor LV function and impaired cardiac conduction. For patients who have undergone pacemaker implantation, upgrading pacemaker to CRT is a good optional strategy of primary surgery with thoracotomy. Further study on indications for implantation of a CRT device during primary surgery is needed.

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