Successful Cardiac Resynchronization Therapy in a 3-Year-Old Girl With Isolated Left Ventricular Non-Compaction and Narrow QRS Complex

A Case Report

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Cardiac resynchronization therapy (CRT) is a new method of treatment for refractory heart failure. However, for children, its indication, efficacy, and long-term prognosis remain unclear. This study describes the use of CRT for a 3-year-old girl with intractable heart failure caused by isolated left ventricular non-compaction (LVNC) with narrow QRS complex. Echocardiography showed diffuse hypokinetic left ventricular (LV) wall motion (ejection fraction = 29.3%) with dysynchrony between the apex, posterior and lateral walls, where numerous prominent trabeculations existed, and severe mitral regurgitation. Biventricular resynchronization using epicardial pacing leads was performed under general anesthesia. Over a follow-up period of 2 years, she exhibited significant and sustained improvement in LV function and clinical symptoms. BNP levels decreased from 1,960 to 82 pg/ml. QRS duration (103 ms) on ECG did not change after CRT. We conclude that pediatric CRT provides a highly useful adjunct for the treatment of heart failure, even in patients with a narrow QRS duration, and might improve the prognosis of patients with LVNC. (Circ J 2009; 73: 2173-2177)

Key Words: Cardiac resynchronization therapy; Children; Heart failure; Isolated left ventricular non-compaction

Case Report

The patient was diagnosed with heart failure caused by isolated LVNC at 3 months of age. LVNC was diagnosed by echocardiographic criteria including: (1) presence of prominent or numerous left ventricular (LV) trabeculations, predominantly in the distal portion (apex) of the left ventricle; (2) a 2-layered structure of the myocardium with an increased non-compacted to compacted ratio (>1.4); and (3) multiple deep intertrabecular recesses communicating with the ventricular cavity, as demonstrated by color Doppler imaging...
Despite full doses of several medications, including angiotensin-converting enzyme inhibitors (enalapril maleate, 0.4 mg·kg\(^{-1}\)·day\(^{-1}\), β-blocker (carvedilol, 0.5 mg·kg\(^{-1}\)·day\(^{-1}\), and pimobendan), she had multiple hospital admissions because of the progression of heart failure (Figure 2). At 3 years of age, she had high fever and hemoptysis, and was diagnosed with pneumonia, which worsened her heart failure and resulted in her 13th hospitalization. Her physical activity was modified New York Heart Association class IV for children. At this latest admission, she weighed 8.3 kg (–3.3 SD), was 77.4 cm tall (–4.3 SD), had a heart rate of 104 beats/min, a blood pressure of 98/62 mmHg, a respiration rate of 38/min, and an oxygen saturation of 95% (room air). Her face was pale and edematous, and wet rales were audible in both lung fields. Her heart sounds were a gallop rhythm, and Levine 3/6 systolic regurgitation murmur and Levine 1/6 diastolic rumbling murmur were audible. Her liver was palpable 3–4 cm below the right costal margin.

A chest X-ray showed marked cardiomegaly (CTR = 0.73) and pulmonary congestion (Figure 3A). An ECG showed a QRS duration of 103 ms (Figure 4). An UCG showed diffuse hypokinetic LV wall motion (ejection fraction (EF) = 29.3%) with obvious dysssynchrony between the apex, poste-
Successful Cardiac Resynchronization Therapy

Figure 3. (A) A chest X-ray on admission, showing marked cardiomegaly (cardiac resynchronization therapy (CRT) = 0.73) and pulmonary congestion. (B) A chest X-ray after 1 year, showing improvement of cardiomegaly (CTR=0.65) and pulmonary congestion. The left ventricular and right ventricular leads were placed epicardially.

Figure 4. An electrocardiogram on admission showed QRS duration of 103 ms. HR = 100, QTc = 0.442 ms.

Biventricular resynchronization using epicardial pacing leads was performed surgically under general anesthesia. By using median sternotomy, we placed an atrial lead, and placed a LV lead at the lateral wall of the apex. On tissue Doppler imaging of the transesophageal echocardiography, intraventricular dyssynchrony between the interventricular septum and apex, posterior and lateral walls, was obvious. Intraventricular delay, measured as a septal to posterior wall delay, was 80.6 ms (Figure 5A, Upper panel). The pacing site of the right ventricular wall was chosen to get optimal synchronization of the ventricular walls on tissue Doppler imaging (Figure 5A, Lower panel), and AV delay was adjusted to achieve maximal systolic blood pressure and maximal cardiac output (Figure 5A).

Over a follow-up period of 2 years, she has exhibited significant and sustained improvement in LV function and clinical symptoms (Table). Serial echocardiographic evaluation revealed that LV dilation improved gradually and continued to improve after 2 years. BNP levels decreased from 1,960 to 82 pg/ml following initiation of CRT (Table). In contrast, QRS duration on ECG did not change after successful CRT. A chest X-ray after 1 year showed improvement of cardiomegaly (CTR=0.65) and pulmonary congestion (Figure 3B). No adverse events, such as arrhythmias, were noted in this patient.

Discussion

This is the first report of successful CRT for a child with severe heart failure (New York Heart Association (NYHA) IV) because of LVNC. In this patient, despite a narrow QRS duration, CRT resulted in the improvement in LV function and clinical symptoms. CRT is a rapidly evolving treatment option for patients with drug-refractory heart failure. Large clinical trials have demonstrated the sustained benefit of CRT in patients with moderate-to-severe heart failure (NYHA functional class III or IV), systolic dysfunction...
The predominant mechanism of benefit from CRT appears to be related to the presence of LV dyssynchrony and subsequent resynchronization after CRT. The presence of baseline LV dyssynchrony might, therefore, be mandatory for a response to CRT. The duration of the QRS complex on the surface ECG has been used as a marker of LV dyssynchrony: however, recent studies demonstrated that QRS duration is only a weak marker of LV dyssynchrony.

CRT appears to be beneficial in patients with narrow QRS complex and severe LV dyssynchrony on tissue Doppler imaging, with similar improvement in symptoms and comparable LV reverse remodeling to patients with wide QRS complexes.

A study of peak systolic velocity interval by tissue Doppler revealed that LV mechanical dyssynchrony is prevalent in pediatric patients with idiopathic dilated cardiomyopathy. QRS duration alone is inadequate to define dyssynchrony in pediatric cardiomyopathy, whereas the adult-derived

**Table. Clinical and Echocardiographic Characteristics Before and After CRT**

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<th>Before CRT</th>
<th>After CRT</th>
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<tbody>
<tr>
<td></td>
<td></td>
<td>1 year</td>
</tr>
<tr>
<td>Age (years, months)</td>
<td>3y7m</td>
<td>4y7m</td>
</tr>
<tr>
<td>Modified NYHA class*</td>
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<td>1</td>
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<tr>
<td>Height (cm)</td>
<td>77.4</td>
<td>89.3</td>
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<tr>
<td>Body weight (kg)</td>
<td>8.4</td>
<td>10.3</td>
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<tr>
<td>Kaup index</td>
<td>14</td>
<td>12.9</td>
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<tr>
<td>BNP (pg/ml)</td>
<td>1,950</td>
<td>82</td>
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<tr>
<td>LVDd (mm) (% of normal)</td>
<td>48 (171%)</td>
<td>45 (154%)</td>
</tr>
<tr>
<td>LVEF (%)</td>
<td>29.3</td>
<td>45.3</td>
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<td>QRS interval (ms)</td>
<td>105</td>
<td>115</td>
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*Modified NYHA class for children 11.

LVDd parenthesis shows % of normal value adjusted for height.

CRT, cardiac resynchronization therapy; NYHA, New York Heart Association; BNP, brain natriuretic peptide; LVDd, left ventricular end-diastolic diameter; LVEF, left ventricular ejection fraction.
dyssynchrony index of >32.6 ms seems applicable to the pediatric population.\textsuperscript{18} An International Multi Center Study, “Resynchronization Therapy in Pediatric and Congenital Heart Disease Patients,” revealed no relationship between baseline EF or QRS duration and EF improvement. There was a significant difference in EF before CRT, with the responders having a lower EF of 24.3±11.0\% vs a 32.0±14.2\% in the non-responders (P=0.04). Only 56 out of 103 patients met the adult criteria for CRT with an EF of ≤35\% and a QRS duration of ≥120 ms.\textsuperscript{19}

In our patient, no adverse events were noted during the follow-up period. Lethal arrhythmias including 3 deaths have been reported in the pediatric CRT population.\textsuperscript{17} Also, acute adverse events such as coronary sinus lead issues, arrhythmic episodes, device pocket hematomas, and 1 each of the following: pocket infection, cerebrovascular accident, bleeding, and perforation of the myocardium requiring surgical intervention, have been reported.\textsuperscript{19} There was an overall adverse event rate of 29\% and the overall mortality was 5\%.\textsuperscript{19} Coronary sinus lead issues, which accounted for 23\% of the reported complications, and were found in 18\% of all transvenous pacemakers placed, were the single most common major complication. No differences in complication rates could be seen when comparing transvenous placement vs epicardial or mixed placement of devices.

\textbf{Conclusion}

We conclude that pediatric CRT provides a highly useful adjunct for the treatment of heart failure, even with narrow QRS duration, and might improve the prognosis of patients with LVNC. CRT is preferable to high-dose inotropic therapy and should be given serious consideration for the treatment of refractory heart failure prior to proceeding with heart transplantation. Further studies are needed to determine the indication, effectiveness, and the long-term benefits of this therapy in the pediatric population.

\textbf{References}