Introduction

Recently cardiac resynchronization therapy (CRT) has been introduced as adjuvant treatment in patients with severe congestive heart failure and bundle branch block. It acutely reduced pulmonary capillary wedge pressure and increased cardiac output. We describe a heart failure patient treated with CRT, whose cardiac functions were evaluated by technetium-99m sestamibi (99mTc-MIBI) electrocardiography-gated single-photon emission computed tomography (SPECT).

Case Presentation

A 65-year-old male with dyspnea and New York Heart Association (NYHA) functional class III heart failure was admitted to our hospital for treatment of heart failure. Eighteen years ago, he had been diagnosed with hypertrophic cardiomyopathy and been treated with digoxin, trichlormethiazide, spironolactone, bisoprolol, fumarate, perindopril, pimobendan, and warfarin. However, severe heart failure recurred several times, requiring admission. Three years ago he had a pacemaker implanted (DDIR mode) because of atrial fibrillation with severe bradycardia. On physical examination, his blood pressure was 118/60, temperature was 36.5°C, pulse rate was 60 per minute and regular. There were pretibial edema and venous distension. A chest X-ray showed pulmonary congestion. He had NYHA functional class III heart failure. Cardiac resynchronization therapy may improve cardiac function as well as dyssynchrony, which could be evaluated non-invasively and accurately by ECG-gated SPECT.

Key words: quantitative gated SPECT (QGS), cardiac resynchronization therapy, cardiac function
atrial natriuretic peptide agent and nitrates. A right heart catheterization showed a mean pulmonary capillary wedge pressure of 18 mmHg. Left ventricular end-diastolic pressure was 18 mmHg. Cardiac output was 3.8 l/min and cardiac index was 2.1 l/(min × m²). He was diagnosed with dilated-phase hypertrophic cardiomyopathy. We decided to place a biventricular system due to the depressed ventricular function and wide QRS interval. Therefore, he was treated with implantation of a biventricular pacemaker (Medtronic, USA). Echo-cardiography revealed that the mitral regurgitation diminished significantly (Fig. 2). He underwent rest 99mTc-MIBI cardiac scintigraphy for evaluation of cardiac function and viability. The patient’s cardiac functions were measured at three different pacing modes; right ventricular (RV) pacing, dual chamber pacing with capture of the ventricles, and left ventricular (LV) pacing. Alterations in pacing mode were done 5 min before the acquisition of the SPECT images. Rest 99mTc-MIBI imaging was performed during biventricular pacing (Fig. 3). At resting condition, the patient received 99mTc-MIBI at a dose of 740 MBq intravenously. A three-headed rotating gamma camera (GCA-9300 A/DI, Toshiba Medical, Japan) equipped with a high-resolution collimator and a medical image processor GMS-5500 U/DI (Toshiba Corporation, Tokyo) was employed for image processing. For gating, 16 frames per cardiac cycle with a re-fixed RR interval and a 15% window were used. Repeated acquisition in the same protocol was performed during RV pacing. And the pacing mode was changed to LV pacing, and the image acquisition was repeated. The myocardial SPETC image was divided into 13 segments. A 4-point scoring system by visual interpretation (3, normal; 2, mildly reduced; 1, severely reduced; 0, no activity) was used. The total perfusion score of 99mTc-MIBI images was calculated as the sum of the scores for all 13 segments. The dysynchrony index (DSI) was defined as the difference in the number of frames showing the maximum systolic move-
In data analysis, the volume curve differentiation software (VCDiff; Daiichi Radioisotope Laboratories, Ltd. Tokyo, Japan) combined with QGS program was applied to process short-axis tomograms to determine left ventricular ejection fraction (LVEF), end-systolic and end-diastolic volume (ESV, EDV), and peak filling rate (PFR).  

Left ventricular parameters during RV pacing were LVEF 28%, EDV 141 ml and ESV 101 ml. And during dual chamber pacing, those were LVEF 31%, EDV 142 ml and ESV 98 ml (Fig. 3). And during LV pacing, those were LVEF 32%, EDV 148 ml and ESV 100 ml. We evaluated his cardiac diastolic function using the VCDiff software. Filling fraction during the first third of diastole were 14.8%, 31.0%, and 49.5% during RV pacing, LV pacing, dual-chamber pacing, respectively. Peak filling rates were 1.12 ml/s (EDV/s) during RV pacing, 1.35 ml/s (EDV/s) during LV pacing, and 1.58 ml/s (EDV/s) during dual-chamber pacing (Fig. 3).

SPECT images showed slightly hypo-perfused myocardium in the inferior segment and apical portion of the left ventricle, with large amount of segments of viability (Fig. 4). Myocardial perfusion score of SPECT images was unchanged before and after CRT (before CRT; 33, after CRT; 33). The DSI before CRT was 4, and changed to 0 after CRT. After 4 weeks of biventricular pacing along with conventional heart failure therapy, the patient showed significant improvement in cardiac function.

**Table 1 Clinical parameters before and after CRT**

<table>
<thead>
<tr>
<th>Parameters</th>
<th>before CRT</th>
<th>After 6 M</th>
<th>After 12 M</th>
</tr>
</thead>
<tbody>
<tr>
<td>BNP, pg/ml</td>
<td>829</td>
<td>603</td>
<td>386</td>
</tr>
<tr>
<td>Systolic BP, mmHg</td>
<td>106</td>
<td>110</td>
<td>112</td>
</tr>
<tr>
<td>Diastolic BP, mmHg</td>
<td>70</td>
<td>68</td>
<td>70</td>
</tr>
<tr>
<td>LVDd, mm</td>
<td>60</td>
<td>58</td>
<td>60</td>
</tr>
<tr>
<td>LVDS, mm</td>
<td>51.4</td>
<td>45.3</td>
<td>44.3</td>
</tr>
<tr>
<td>LVEF, mm</td>
<td>30</td>
<td>43.6</td>
<td>50.5</td>
</tr>
<tr>
<td>%FS</td>
<td>14.0</td>
<td>21.9</td>
<td>26.2</td>
</tr>
<tr>
<td>LAD, mm</td>
<td>57</td>
<td>54</td>
<td>54</td>
</tr>
<tr>
<td>NYHA class</td>
<td>III</td>
<td>1</td>
<td>1</td>
</tr>
</tbody>
</table>

CRT: cardiac resynchronization therapy, BNP: brain natriuretic peptide, BP: blood pressure, LVDd: left ventricular end-diastolic diameter, LVDS: left ventricular end-systolic diameter, %FS: percent fractional shortening. LAD: left atrial diameter. NYHA class: New York Heart Association functional class.
therapy, his NYHA functional class improved from III to I, and partial LV reverse remodeling was achieved (Table 1). An electrocardiogram with CRT showed the QRS interval was markedly improved at 172 ms (Fig. 1). After treatment with CRT, the patient has been uneventful for two years.

**DISCUSSION**

The addition of gating to routine myocardial perfusion SPECT provides accurate and reproducible information on left ventricular function. \(^{99mTc}\)-MIBI gated SPECT provides quantitatively global functional parameters including EDV, ESV and LVEF as well as PFR in a patient with CRT. \(^6\) Several studies \(^{7,10}\) compared gated SPECT with standard radionuclide techniques for the measurement of left ventricular function and found it was accurate and reproducible. The present case showed that LVEF in dual-chamber pacing was higher than in RV pacing. Furthermore the left ventricular filling was evaluated as an index of left ventricular compliance in this case. In this case, PFR during dual-chamber pacing was higher than that of right ventricular pacing in the same heart rate. This may indicate that early diastolic relaxation was improved with CRT. In previous studies, CRT was reported to improve exercise tolerance, functional class and quality of life and decrease hospitalizations due to heart failure in large trials. \(^{1,2}\) Extensive evidence has shown that CRT provides acute and long-term clinical benefits in selected patients with heart failure. Dyssynchrony can be induced by artificial pacemaker and this can itself lead to LV systolic failure. \(^{11}\)

The beneficial effects of CRT on left ventricular performance may be caused by mechanisms not associated with myocardial work in single contracting segments. Such mechanisms may include a better coordination of left ventricular segmental contraction (resynchronization), a prolongation of diastole, a reduction in the severity of mitral regurgitation, and a better atrial-ventricular synchrony. Although we have current methods of imaging ventricular asynchrony by Doppler tissue imaging, ECG-gated SPECT provides accurate and reproducible information on dyssynchrony, that could be evaluated non-invasively and accurately by ECG-gated cardiac scintigraphy.

**REFERENCES**


4. Matsuo S, Nakae I, Matsumoto T, Horie M. Cardiac resynchronization therapy may improve both cardiac systolic and diastolic function as well as dyssynchrony, that could be evaluated non-invasively and accurately by ECG-gated cardiac scintigraphy.


