NON-INVASIVE ASSESSMENT OF LEFT VENTRICULAR FUNCTION AND PROGNOSIS IN ACUTE MYOCARDIAL INFARCTION
—Clinical Significance of B-B' Step of the Mitral Valve in M-mode Echocardiography—

TOHRU SAITO, M.D.

On 37 patients with acute myocardial infarction (AMI), M-mode echocardiography was performed sequentially from the onset of the disease for more than 20 days in order to study the significance of a B-B' step of the anterior mitral valve in AMI. The following results were obtained: 1) A B-B' step was observed in 60% of the patients studied, and the incidence was higher in anteroseptal than posteroinferior infarction. 2) A B-B' step was especially noticed in the patients who had left ventricular failure. 3) The prognosis of the patients with a B-B' step was worse than that of the patients without it. A B-B' step, which either persisted for longer than 10 days or developed into a more definite form with the course of time, was a sign of an unfavorable prognosis. 4) The patients with a B-B' step had higher mean pulmonary arterial pressure than the patients without it.

These results suggest that serial observations of the B-B' step in patients with AMI were a useful means to evaluate the left ventricular function and to determine prognosis in this disorder.

One of the serious complications in acute myocardial infarction (AMI) is a decreased left ventricular function which may lead to a congestive heart failure or cardiogenic shock. Therefore, it is important to know the extent of the asynergic myocardial segment, the changes in the left ventricular function and the size and site of myocardial infarction, especially in its early stage. While the measurements using a Swan-Ganz catheter have been carried out to evaluate these findings, M-mode echocardiography, having the advantage of being non-invasive, has also been applied for this purpose. However, the validities of the most of M-mode echocardiographic parameters proposed to evaluate hemodynamic changes have not yet been fully accepted in AMI. The purpose of the present study is to evaluate the clinical significance of the B-B' step of the anterior mitral valve on a M-mode echocardiogram and to analyze the relationship between the B-B' step and hemodynamic changes of the left ventricle in the patient with AMI in its early stage.

Key Words:
Echocardiography
B-B' step
Mean pulmonary arterial pressure
Acute myocardial infarction

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MATERIALS AND METHODS

The subjects studied were 37 patients with AMI, 31 males and 6 females, ranging in age from 28 to 80 (average 59). The sites of infarction were antero-septal in 19 cases, postero-inferior in 17 and subendocardial in one. Their diagnoses were established based on clinical symptoms, ECG and enzymatic studies of the sera. Sixteen cases had congestive heart failure as evidenced by dyspnea, gallop rhythms, and pulmonary congestion by physical and radiographic criteria.

Aloka SSD-110 and SSD-80 were used for M-mode echocardiography. Their images were obtained at 2.25 MHz with a plane transducer of 15 mm in diameter and photographed by a Polaroid camera.

The echograms were taken in supine-position or in a 30-degree lateral decubitus position. The ultrasonic-beam was projected from the left sternal edge at the 3rd or 4th intercostal space, to the direction in which the motion of the anterior mitral valve showed its maximal amplitude and the B-B' step demonstrated.

In 26 cases, mean pulmonary arterial pressure (mPAP) was measured by cardiac catheterization. A Swan-Ganz catheter of Model 93A-131-7F and Cardiac Output Computer 9520 (Edwards) were used for hemodynamic measurements, and Polygraph 6000, Bedside Monitor WEP-6200 (Nihon Koden) and 78342A Multi-monitor (Hewlett Packard) for pressure monitoring.

At least 4 serial echograms were obtained for each patient during the observation period from the onset of the disease for more than 20 days.

RESULTS

B-B' step of the anterior mitral valve (Fig. 1) was seen in 60% of the total patients studied. The incidence was higher in patients with antero-septal infarction than those with the postero-inferior type as shown in Table I. It was particularly high in patients who had left ventricular failure (Table II). Of the 7 patients who died during the period of the study, 5 had a B-B' step. The cause of death in one of the remaining 2, who had no B-B' step, was non-cardiac in nature (Table III). All 6 severe cases who were classified as Class II or III according to the functional classification of the New York Heart Association had a B-B' step, while 12 of 23 patients of Class I showed no B-B' step during the period of observation. The patients who showed B-B' step only for a short period (less than 10 days after the onset) seemed to have a relatively favorable prognosis, and 7 of these 9 cases were classified as Class I. On the other hand, the prognosis of the patients whose B-B' step persisted for longer period was unfavorable, and 6 of the 9 were Class II or III. The prognosis was especially unfavorable in the patients, in whom a B-B' step appeared in the later stages or became more marked with the course of time, and 3 of 4 died during the period of hospitalization (Table IV).

<table>
<thead>
<tr>
<th>TABLE I</th>
<th>THE INCIDENCE OF B-B' STEP IN ACUTE MYOCARDIAL INFARCTION: A COMPARISON BETWEEN ANTERO-SEPTAL AND POSTERO-INFERIOR INFARCTION</th>
</tr>
</thead>
<tbody>
<tr>
<td>B-B' step</td>
<td>Total patients</td>
</tr>
<tr>
<td></td>
<td>No. (%)</td>
</tr>
<tr>
<td>Positive</td>
<td>22 (60)</td>
</tr>
<tr>
<td>Negative</td>
<td>15 (40)</td>
</tr>
<tr>
<td>Total</td>
<td>37 (100)</td>
</tr>
</tbody>
</table>

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TABLE II  THE INCIDENCE OF B-B' STEP IN PATIENTS WITH ACUTE MYOCARDIAL INFARCTION ASSOCIATED WITH OR WITHOUT LEFT VENTRICULAR FAILURE (HF)

<table>
<thead>
<tr>
<th>B-B' step</th>
<th>Total patients</th>
<th>Patients ≤HF</th>
<th>Patients ≥HF</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>No. (% )</td>
<td>No. (%)</td>
<td>No. (%)</td>
</tr>
<tr>
<td>Positive</td>
<td>22 ( 60 )</td>
<td>14 ( 88 )</td>
<td>8 ( 38 )</td>
</tr>
<tr>
<td>Negative</td>
<td>15 ( 40 )</td>
<td>2 ( 12 )</td>
<td>13 ( 62 )</td>
</tr>
<tr>
<td>Total</td>
<td>37 (100)</td>
<td>16 (100)</td>
<td>21 (100)</td>
</tr>
</tbody>
</table>

TABLE III  THE RELATIONSHIP BETWEEN THE INCIDENCE OF B-B' STEP AND THE SEVERITY OF INFARCTION AND PROGNOSIS

<table>
<thead>
<tr>
<th>Severity &amp; prognosis</th>
<th>Total patients</th>
<th>Patients ≤ B-B' step</th>
<th>Patients ≥ B-B' step</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>No. (%)</td>
<td>No. (%)</td>
<td>No. (%)</td>
</tr>
<tr>
<td>NYHA I</td>
<td>23 ( 62 )</td>
<td>11 ( 50 )</td>
<td>12 ( 80 )</td>
</tr>
<tr>
<td>NYHA II-III</td>
<td>6 ( 16 )</td>
<td>6 ( 27 )</td>
<td>0 ( 0 )</td>
</tr>
<tr>
<td>Dead</td>
<td>7* ( 19 )</td>
<td>5 ( 23 )</td>
<td>2* ( 13 )</td>
</tr>
<tr>
<td>Unknown</td>
<td>1 ( 3 )</td>
<td>0 ( 0 )</td>
<td>1 ( 7 )</td>
</tr>
<tr>
<td>Total</td>
<td>37 (100)</td>
<td>22 (100)</td>
<td>15 (100)</td>
</tr>
</tbody>
</table>

* One died of a non-cardiac cause.

The mPAP was compared in the patients with a B-B’ step and those without it (Fig. 2). The mean ± SD of mPAP of the former was 22.8 ± 5.7 mmHg, and that of the latter was 16.6 ± 4.7, and the difference between the two was statistically significant (p < 0.01). As shown in Fig. 3, a higher mPAP was seen at the onset of the disease in the patients who showed a B-B’ step. Although it decreased gradually during the first 7 days, it was still higher at the 7th day than that in the patients who had no B-B’ step.

DISCUSSION

Mitral valve motion may be influenced greatly by the hemodynamic changes of the left heart. In the case of AMI, the presence of asynchrony in the left ventricle has little effect on this motion, and therefore, echocardiographic parameters related to this motion, such as diastolic descent rate (DDR), the A/E ratio of the anterior mitral valve (A/E)², or PR-AC interval³ have been proposed as indexes of the left ventricular function. However, there are controversies about the validities of echocardiographic parameters in AMI⁴,⁵,⁶

The B-B’ step of the anterior mitral valve, which is easy to detect on a M-mode echocardiogram has been pointed out to be a sign of left ventricular failure by some authors⁷,⁸,⁹,¹⁰ The possible causes of the presence of a B-B’ step of the mitral valve are multiple. For the most part, the B-B’ step is an interruption of mitral valve closure (prolongation of A-C interval) due to an instantaneously occurring plateau of pressure gradient between the left atrium and the left ventricle resulting from a decreased enddiastolic stretch of the left ventricle or from a decreased velocity of left ventricular contraction. The other cause is a mechanical segregation between atrial and ventricular contraction, rapid changes in pressure gradient between the left atrial and the left ventricle and changes of tension in the chordae tendineae.¹¹ In myocardial infarction, besides the impaired stretching of the damaged myocardium, a decrease in contraction may also account for the presence of ischemia, resulting in a delay of intraventricular pressure elevation, which, in turn, causes the formation of a B-B’ step. According to Machii,¹² a B-B’ step can be corroborated when the end-diastolic pressure ex-
<table>
<thead>
<tr>
<th>No</th>
<th>Case</th>
<th>Age</th>
<th>Sex</th>
<th>Infarction Site</th>
<th>Course of B-B' step</th>
<th>Severity and Prognosis</th>
<th>Follow-up period (month)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>&lt; 2 days</td>
<td>3–4 days</td>
<td>7–10 days</td>
</tr>
<tr>
<td>1</td>
<td>N.Y.</td>
<td>59</td>
<td>M</td>
<td>P-I</td>
<td>+</td>
<td>+</td>
<td>–</td>
</tr>
<tr>
<td>2</td>
<td>F.T.</td>
<td>55</td>
<td>M</td>
<td>A-S</td>
<td>+</td>
<td>+</td>
<td>–</td>
</tr>
<tr>
<td>3</td>
<td>K.K.</td>
<td>72</td>
<td>M</td>
<td>P-I</td>
<td>+</td>
<td>+</td>
<td>+</td>
</tr>
<tr>
<td>4</td>
<td>S.O.</td>
<td>52</td>
<td>M</td>
<td>P-I</td>
<td>+</td>
<td>+</td>
<td>–</td>
</tr>
<tr>
<td>5</td>
<td>H.S.</td>
<td>74</td>
<td>F</td>
<td>P-i</td>
<td>+</td>
<td>–</td>
<td>–</td>
</tr>
<tr>
<td>6</td>
<td>M.S.</td>
<td>45</td>
<td>M</td>
<td>A-S</td>
<td>+</td>
<td>?</td>
<td>–</td>
</tr>
<tr>
<td>7</td>
<td>I.T.</td>
<td>55</td>
<td>M</td>
<td>A-S</td>
<td>–</td>
<td>+</td>
<td>–</td>
</tr>
<tr>
<td>8</td>
<td>T.N.</td>
<td>55</td>
<td>M</td>
<td>A-S</td>
<td>+</td>
<td>+</td>
<td>–</td>
</tr>
<tr>
<td>9</td>
<td>T.K.</td>
<td>70</td>
<td>M</td>
<td>A-S</td>
<td>+</td>
<td>+</td>
<td>–</td>
</tr>
<tr>
<td>10</td>
<td>T.S.</td>
<td>59</td>
<td>M</td>
<td>A-S</td>
<td>+</td>
<td>+</td>
<td>+</td>
</tr>
<tr>
<td>11</td>
<td>S.T.</td>
<td>70</td>
<td>M</td>
<td>A-S</td>
<td>+</td>
<td>+</td>
<td>+</td>
</tr>
<tr>
<td>12</td>
<td>R.N.</td>
<td>40</td>
<td>M</td>
<td>A-S</td>
<td>+</td>
<td>+</td>
<td>+</td>
</tr>
<tr>
<td>13</td>
<td>T.B.</td>
<td>57</td>
<td>M</td>
<td>A-S</td>
<td>+</td>
<td>+</td>
<td>–</td>
</tr>
<tr>
<td>14</td>
<td>M.A.</td>
<td>44</td>
<td>M</td>
<td>A-S</td>
<td>+</td>
<td>+</td>
<td>–</td>
</tr>
<tr>
<td>15</td>
<td>Y.S.</td>
<td>65</td>
<td>M</td>
<td>P-I</td>
<td>+</td>
<td>+</td>
<td>+</td>
</tr>
<tr>
<td>17</td>
<td>K.W.</td>
<td>66</td>
<td>M</td>
<td>P-I</td>
<td>+</td>
<td>+</td>
<td>+</td>
</tr>
<tr>
<td>19</td>
<td>Y.M.</td>
<td>57</td>
<td>M</td>
<td>A-S</td>
<td>–</td>
<td>–</td>
<td>+</td>
</tr>
<tr>
<td>20</td>
<td>S.S.</td>
<td>70</td>
<td>F</td>
<td>A-S</td>
<td>+</td>
<td>+</td>
<td>++</td>
</tr>
<tr>
<td>21</td>
<td>K.K.</td>
<td>60</td>
<td>F</td>
<td>A-S</td>
<td>–</td>
<td>–</td>
<td>+</td>
</tr>
<tr>
<td>22</td>
<td>M.S.</td>
<td>46</td>
<td>M</td>
<td>A-S</td>
<td>–</td>
<td>–</td>
<td>+</td>
</tr>
</tbody>
</table>

A-S = antero-septal, P-I = postero-inferior, (–) = B-B’ step negative, (+) = B-B’ step positive, (++ = more marked B-B' step than (+), (?) = doubtfull B-B’ step, I or II-III = functional class of New York Heart Association
ceeds 15 mmHg, and that it disappear with the improvement of the condition. Shiotani\(^{10}\) noted a B-B' step more frequently in antero-septal infarction than in the postero-inferior type, and stated that a B-B' step is a sign of an unfavorable prognosis, because the damaged area is relatively wider in antero-septal infarction than in the infarction of other sites, resulting in a greater decline of the left ventricular function.\(^{13}\)

In the present study, B-B' step was demonstrated more frequently in patients with antero-septal infarction than those with postero-inferior one. The incidence of a B-B' step was especially high when heart failure was evident, and it correlated with the severity of the disease. Most of the patients who showed B-B' step for longer than 10 days from the onset were severe cases. Moreover, all of the patients whose B-B' step developed into a more marked one during their disease course, died during the period of hospitalization.

The relation between the B-B' step and the reduction of the left ventricular function described in the present study by comparing mPAP in B-B' step positive and negative cases. The mPAP was significantly elevated in B-B' step positive cases than the negative ones, and it was particularly elevated at the onset of the disease and remained high during the first 7 days in the former cases.

These results suggest that B-B' step is a sign of left ventricular failure and of the unfavorable prognosis of AMI. Corya et al.\(^{14}\) reported that the cases with left ventricular failure had a prolonged PR-AC interval, and LVDd index/PR-AC correlated with the mortality rate of the patients. However, this index is difficult to determine in some cases. Moreover, it is necessary to correct based upon the heart rate. In contrast, B-B' step of the anterior mitral valve is easy to detect on M-mode echocardiogram. It is concluded that a B-B' step is a sign of left ventricular failure, and its corroboration and its serial observations were proven valid by predictions of the prognosis in patients with AMI.

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