Primary aldosteronism, one of the secondary hypertensive diseases, is produced by excessive aldosterone excretion from adrenal adenoma. Left ventricular hypertrophy in primary aldosteronism is thought to be due to hypertension, together with elevated circulating aldosterone levels. Left ventricular hypertrophy is the result of structural adaptation of the hypertensive heart and occurs in response to increased hemodynamic and metabolic factors such as catecholamine and angiotensin II. Some studies have demonstrated that not only the progressive hypertrophy of myocytes but also interstitial fibrosis were observed in hypertensive heart, and the histological changes were dependent on arterial hypertension together with elevated circulating aldosterone levels. These findings suggest that there is a difference in myocardial damage associated with hypertension between essential hypertension and primary aldosteronism.

Recently, thallium-201 myocardial scintigraphy has been used as the most reliable method for the evaluation of myocardial damage in various heart diseases. The aim of this study was to elucidate with the use of thallium-201 myocardial scintigraphy whether a difference in myocardial damage exists between primary aldosteronism and essential hypertension.

Methods

Study Population

Twenty normotensive control subjects, 10 patients with surgically proven primary aldosteronism, and 10 patients with untreated essential hypertension participated in this study; they were matched for age, sex, and blood pressure levels for primary aldosteronism. Blood pressure was measured with a standard mercury sphygmomanometer after patients had rested 5 minutes in the sitting position. Plasma renin activity and plasma aldosterone concentration were measured by radioimmunoassay. Subjects who had coronary artery disease, valvular heart disease, left bundle branch block, or other conduction disturbances were excluded. The clinical and hemodynamic characteristics in all subjects are summarized in the Table. Electrocardiographic, echocardiographic, and thallium-201 myocardial scintigraphic examinations were performed in all subjects. All patients with primary aldosteronism repeated these examinations approximately 3 months after operation (3.6±1.2 months). Details of the examinations were explained to each person, and each gave free consent.

Electrocardiography

The sum of the S wave in V1 and R wave in V5 was calculated as the electrocardiographic index of left ventricular hypertrophy according to the method of Sokolow and Lyon.

Echocardiography

Echocardiographic examinations were carried out with an Aloka SSD 870 imaging system (Tokyo, Japan) using a 3.5-MHz transducer 48 hours after the discontinuation of all medications. The internal dimensions of the left ventricle and the thicknesses of the interventricular septum and left ventricular posterior wall were measured according to the recommendations of the American Society of Echocardiography. Left ventricular mass was then estimated by the formula of Devereux and Reichek and was divided by body surface area (left ventricular mass index). All measurements were carried out over three consecutive cardiac cycles and averaged with the aid of a computer interfaced with a graphic analyzer.

Thallium-201 Myocardial Scintigraphy

Of the 10 patients with primary aldosteronism, only 1 had received 40 mg of nifedipine per day; the other 9 patients had received no medical treatment before thallium-201 myocardial single-photon emission computed tomography. Thallium-201 myocardial scintigraphy was performed 48 hours after the discontinuation of all medications and was obtained with...
Clinical, Echocardiographic, and Electrocardiographic Data in Normotensive Control Subjects and Patients With Essential Hypertension and Primary Aldosteronism

<table>
<thead>
<tr>
<th>Parameter</th>
<th>NC (n=20)</th>
<th>EHT (n=10)</th>
<th>PA (n=10)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Age, y</td>
<td>56±10</td>
<td>52±8</td>
<td>50±8</td>
</tr>
<tr>
<td>Sex, M/F</td>
<td>10/10</td>
<td>4/6</td>
<td>4/6</td>
</tr>
<tr>
<td>BSA, m²</td>
<td>1.5±0.3</td>
<td>1.6±0.3</td>
<td>1.6±0.2</td>
</tr>
<tr>
<td>SBP, mm Hg</td>
<td>123±7</td>
<td>183±29*</td>
<td>181±13*</td>
</tr>
<tr>
<td>DBP, mm Hg</td>
<td>63±16</td>
<td>107±14*</td>
<td>103±6*</td>
</tr>
<tr>
<td>HR, bpm</td>
<td>65±7</td>
<td>68±4</td>
<td>68±4</td>
</tr>
<tr>
<td>LVDd, cm</td>
<td>4.7±0.6</td>
<td>5.1±0.5†</td>
<td>4.9±0.3†</td>
</tr>
<tr>
<td>LVDs, cm</td>
<td>3.0±0.4</td>
<td>3.3±0.4†</td>
<td>3.0±0.5</td>
</tr>
<tr>
<td>FS, %</td>
<td>36.2±5.3</td>
<td>34.7±5.4</td>
<td>39.1±6.9</td>
</tr>
<tr>
<td>IVST, cm</td>
<td>0.8±0.1</td>
<td>1.0±0.2*</td>
<td>1.0±0.2*</td>
</tr>
<tr>
<td>PWT, cm</td>
<td>0.8±0.1</td>
<td>1.0±0.2*</td>
<td>1.0±0.2*</td>
</tr>
<tr>
<td>LVMI, g/m²</td>
<td>86±13</td>
<td>149±46*</td>
<td>135±30*</td>
</tr>
<tr>
<td>SV₁+RV₄, mL</td>
<td>1.8±0.6</td>
<td>4.3±1.2*</td>
<td>4.6±1.4*</td>
</tr>
<tr>
<td>PRA, (ng Ang I/mL)/h</td>
<td>1.4±0.6</td>
<td>1.8±1.1</td>
<td>0.4±0.5†</td>
</tr>
<tr>
<td>PAC, pg/mL</td>
<td>101±39</td>
<td>102±36</td>
<td>236±110*†</td>
</tr>
</tbody>
</table>

NC indicates normotensive control; EHT, essential hypertension; PA, primary aldosteronism; BSA, body surface area; SBP, systolic blood pressure; DBP, diastolic blood pressure; HR, heart rate; bpm, beats per minute; LVDd, left ventricular end-diastolic dimension; LVDs, left ventricular end-systolic dimension; FS, fractional shortening; IVST, interventricular septal thickness; PWT, posterior wall thickness; LVMI, left ventricular mass index; SV₁+RV₄, sum of S wave in V₁ and R wave in V₄; PRA, plasma renin activity; Ang I, angiotensin I; and PAC, plasma aldosterone concentration. Values are mean±SD.

*p<.01, †p<.05 vs NC.  
‡p<.01 vs EHT.

Baseline Characteristics of the Subjects
The Table shows the backgrounds of all subjects. Baseline characteristics in primary aldosteronism were matched for age, sex, body surface area, and blood pressure levels for untreated essential hypertension. There were no significant differences in left ventricular dimension and the severity of myocardial hypertrophy between patients with primary aldosteronism and essential hypertension.

Thallium-201 Myocardial Scintigraphic Findings
Fig 1 shows the extent scores in patients with essential hypertension and primary aldosteronism. The extent score in patients with primary aldosteronism (45.8±23.5%) was markedly greater than that in patients with essential hypertension (9.5±7.3%, P<.01). Fig 2 shows bull's-eye maps of representative cases in a patient with primary aldosteronism (A) and essential hypertension (B). The thallium-201 defects in patients with primary aldosteronism were not segmental but widely distributed, centering around the apex.

Changes in Echocardiographic and Electrocardiographic Findings and Extent Scores in Patients With Primary Aldosteronism Before and After Operation
Two to 3 weeks after operation, serum potassium and plasma aldosterone levels changed from 2.9±0.2 to 4.1±0.9 mmol/L and 236±110 to 57±31 pg/mL, respectively. Three months after operation, systolic and diastolic blood pressures decreased from 181±13 to 150±14 mm Hg (P<.01) and 103±6 to 83±5 mm Hg.
p<0.05

FIG 2. Bull’s-eye maps show representative cases in patients with primary aldosteronism (A) and essential hypertension (B). (P<.01), respectively. Left ventricular mass index and SV$_1$+RV$_5$ were changed from 135±29 to 119±21 g/m$^2$ (P<.05) and 4.6±1.5 to 3.8±0.9 mV (P<.05), respectively. The extent score was improved from 45.8±23.5% to 29.7±20.5% (P<.05) as shown in Fig 3.

Discussion

The major findings of this study are that the defect of thallium-201 uptake was significantly greater in primary aldosteronism than in essential hypertension, despite the matching of blood pressure levels and severity of left ventricular hypertrophy, and was improved in most patients with primary aldosteronism 3 months after operation.

The defect of thallium-201 perfusion expressed as extent score is usually used as an index of the expansion of myocardial ischemia in patients with myocardial infarction. Recently, thallium-201 myocardial scintigraphy is also used as the method of estimating myocardial viability in hibernating myocardium. Decrease in volume and function of the left ventricular myocyte is chiefly related to the defect of thallium-201 perfusion. In our study, the thallium-201 defects in patients with primary aldosteronism were not segmental but widely distributed. This finding suggests that high extent score in patients with primary aldosteronism is not due to the abnormality of coronary perfusion. Thus, a markedly high extent score in patients with primary aldosteronism may reflect severe myocardial damage. Several factors must be considered for this reason.

Although there were no differences in left ventricular mass index and SV$_1$+RV$_5$ between patients with essential hypertension and primary aldosteronism, the severity of myocardial damage associated with hypertension may differ between the two groups. Aldosterone may have deleterious effects on not only collagen metabolism but also myocytes. Thus, it is conceivable that myocardial damage is more severe in primary aldosteronism than in essential hypertension. The next important factor is the increased interstitial spaces with interstitial fibrosis. Myocyte hypertrophy occurs and is associated with hypertension, but hyperplasia does not occur. On the contrary, hypertension stimulates the hyperplasia of interstitial cells, which results in the decrease of the ratio of myocyte volume to collagen volume. The increase in circulating aldosterone in primary aldosteronism may accelerate this ratio, and a relatively low volume in myocytes in primary aldosteronism seems to be responsible for the high extent score.

Another factor for a high extent score in primary aldosteronism is the effect of low plasma potassium itself on cardiac function. Potassium and thallium presumably compete for the same transport mechanism. In rat experiments, urinary excretion of thallium is enhanced and thallium toxicity is decreased by the administration of potassium chloride. Therefore, under the condition of potassium depletion in primary aldosteronism, thallium excretion may be reduced and thallium toxicity thereby increased. In our study, however, extent score still remained high, despite the normalization of serum potassium after operation. This finding, therefore, may indicate that low serum potassium itself is not markedly related to the high extent score in primary aldosteronism.

After operation, the extent score in primary aldosteronism was significantly decreased. Left ventricular mass index and SV$_1$+RV$_5$ were also decreased. The decrease in extent score seems to be mainly related to the regression of myocardial hypertrophy associated with the normalization of blood pressure. In addition,
the decrease in collagen volume may occur by the normalization of plasma aldosterone concentration and blood pressure. If so, the decrease in collagen volume is another reason for the decrease in extent score.

References
Myocardial scintigraphic characteristics in patients with primary aldosteronism.
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