Assessment of the Severity of Coronary Artery Disease by Thallium-201 Washout Rate after Dipyridamole Infusion

—— A Coronary Hemodynamic and Metabolic Study ——

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This study examined the relationship between the myocardial washout rate (WR) of thallium-201 (201 TI) in dipyridamole scintigraphy and both coronary flow reserve (CFR) and myocardial lactate extraction rate (LER) after dipyridamole infusion in 31 patients with coronary artery disease (CAD) without myocardial infarction and 16 control patients. Patients with CAD demonstrated significantly lower WR (21 ± 17 vs 43 ± 10%, p < 0.001), lower CFR (128 ± 82 vs 242 ± 89%, p < 0.001) and lower LER (−2 ± 20 vs 10 ± 10%, p < 0.05) than did the control patients. WR was significantly correlated with CFR (r = 0.50, p < 0.001) and LER (r = 0.41, p < 0.01) in all of the patients. CAD patients with dipyridamole-induced chest pain demonstrated significantly lower WR (14 ± 20 vs 27 ± 12%, p < 0.05), lower CFR (97 ± 71 vs 162 ± 82%, p < 0.05) and lower LER (−13 ± 21 vs 11 ± 9%, p < 0.001) than did CAD patients without chest pain. CAD patients with dipyridamole-induced ST depression demonstrated significantly lower WR (14 ± 20 vs 29 ± 8%, p < 0.05), lower CFR (105 ± 79 vs 170 ± 73%, p < 0.05) and lower LER (−8 ± 21 vs 11 ± 10%, p < 0.01) than did CAD patients without ST depression. These results suggest that the myocardial washout rate of 201 TI after dipyridamole infusion reflects the severity of coronary artery disease as assessed by coronary hemodynamics, myocardial metabolism, symptoms and electrocardiography. (Jpn Circ J 1995; 59: 11–22)

MYOCARDIAL thallium washout analysis has been adopted as an adjunct to the qualitative or quantitative assessment of regional defects using exercise stress thallium-201 (201 TI) scintigraphy.¹⁻³ Dipyridamole 201 TI scintigraphy is an alternative to exercise stress for the evaluation of coronary artery disease, especially in patients who cannot undergo exercise testing.⁴⁻⁸ Some authors have reported that the washout rate is slower in dipyridamole imaging than in exercise imaging and that washout rate analysis is less useful with dipyridamole imaging than with exercise imaging.⁹⁻¹¹ However, others have demonstrated that washout rate analysis is useful for detecting patients with severe coronary artery disease, such as those with left main coronary artery

Key words:
- Washout rate
- Dipyridamole thallium scintigraphy
- Coronary blood flow
- Myocardial ischemia

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coronary blood flow and myocardial ischemia. Therefore, the goal of the present study was to investigate the relationship of scintigraphic findings and washout rate to the findings of invasive studies of coronary blood flow and myocardial metabolism after dipyridamole infusion in humans. We also investigated the relation of dipyridamole-induced chest pain and ST segment depression to the washout rate, coronary blood flow and myocardial metabolism.

METHODS

Subjects
Forty-seven patients who underwent dipyridamole $^{201}$TI scintigraphy and coronary angiography for suspected coronary artery disease were included in the study. They were classified into two groups: 16 patients with no coronary artery disease (Control; 6 men and 10 women; mean age, 50±11 years) and 31 patients with coronary artery disease (CAD; 25 men and 6 women; mean age, 58±9 years). Patients were selected on a consecutive basis according to the following criteria: 1) angiographic documentation of normal coronary arteries for control patients, 2) angiographic documentation of more than 50% luminal diameter stenosis of the proximal left anterior descending coronary artery (LAD) for patients with CAD, 3) the presence of conditions that made it possible to catheterize the great cardiac vein with a thermodilution catheter and to easily sample the blood from the vein and 4) no history or ECG evidence of prior myocardial infarction. Patients who had previous coronary artery bypass grafting, or transluminal coronary angioplasty were excluded from the study. Patients with unstable angina, congenital heart disease and valvular heart disease were also excluded from the study. Of the 31 patients with CAD, 17 had single vessel disease, 8 had double vessel disease, and 6 had triple vessel disease. The visually assessed luminal diameter coronary stenosis of the LAD was 51% to 75% in 4 patients, 76% to 90% in 12 patients, 91% to 99% in 12 patients, and 100% in 3 patients. Well-developed collaterals defined as opacification of the LAD were seen in 7 patients with CAD, including the 3 patients with total occlusion of the...
LAD. Left ventriculograms were normal in all patients. Catheterization and dipyridamole 201Tl scintigraphy were performed within 2 months of each other in all patients and at least 24 h after discontinuation of cardiac medications. No clinical events occurred between the angiographic and scintigraphic studies. Written informed consent was obtained from all of the patients.

**Cardiac Catheterization**

Patients underwent coronary arteriography and left ventriculography in multiple projections using the standard Judkins technique. A thermodilution catheter (Wilton-Webster) was introduced into the right atrium percutaneously via the right internal jugular vein. The great cardiac vein, which drains most of the blood which flows from the myocardium in the distribution of the LAD, was cannulated via the coronary sinus. Great cardiac vein flow (ml/min) was measured by the thermodilution method. Care was taken that the catheter tip was stable without baseline drift on the thermodilution signal. Arterial pressure was measured with the sidearm of a vascular sheath apparatus placed in the right femoral artery. Arterial and great cardiac vein blood samples were obtained simultaneously for lactate and oxygen analysis. Lactate content was measured with an automatic analyzer (Diagluca, Toyobo). Myocardial lactate extraction rate (%) was calculated as follows: arterial lactate – great cardiac vein lactate/arterial lactate × 100. Oxygen saturation values were measured with an automatic blood gas analyzer (ABL-2, Radiometer). Oxygen content was calculated using the formula: oxygen saturation × hemoglobin concentration × 1.34. Coronary arteriovenous oxygen difference was determined by comparing coronary artery and vein oxygen content. Myocardial oxygen consumption was calculated by multiplying great cardiac vein flow and coronary arteriovenous oxygen difference.

After completion of basal measurements, 0.568 mg/kg of dipyridamole was injected intravenously over 4 min. Repeat pressure and flow measurements and blood sampling were performed 3 min after the end of dipyridamole infusion. Coronary flow reserve was calculated as the percent change in great cardiac vein flow from baseline to dipyridamole infusion time. A 12-lead ECG was obtained at baseline and every minute for 15 min after the beginning of dipyridamole infusion. The ECGs were interpreted as positive for ischemia in the presence of ≥ 1 mm horizontal or downsloping ST-segment depression.

**Dipyridamole Thallium-201 Scintigraphy**

Three minutes after the infusion of the same dose of dipyridamole as that used in the catheterization study, 2 mCi (74 MBq) of 201Tl was injected intravenously. A 12-lead ECG was obtained at baseline and every minute for 8 min after the beginning of the infusion. Cardiac imaging was begun 10 min after the injection of 201Tl, and was repeated 3 h later. A rotatable camera
Fig. 2. Left: Great cardiac vein flow at baseline (Base) and after dipyridamole infusion (Dip) in 16 control patients and 31 patients with coronary artery disease (CAD). Right: Coronary flow reserve (defined as the percent change in great cardiac vein flow from baseline) in 16 control patients and 31 patients with CAD.

Fig. 3. Myocardial lactate extraction rate at baseline (Base) and after dipyridamole infusion (Dip) in 16 control patients and 31 patients with coronary artery disease (CAD).

(ZLC-7500, Siemens) equipped with a low-energy, high-resolution collimator and interfaced with a digital computer (Scintipac-2400, Shimadzu) was used for all studies. Thirty-two planar views were obtained (20 sec/view) during a 180-degree rotation from the 45 degree right anterior oblique to the 45 degree left posterior oblique projection. Images were reconstructed by a filtered back projection method without attenuation correction. Orthogonal images were generated by oblique angle reconstruction which produced short-axis, vertical long-axis, and horizontal long-axis slices, each 6-mm thick. Circumferential profile analysis was applied to each of the short-axis slices from apex to base. These circumferential profiles were plotted in polar coordinates and arranged into bull’s-eye map. This procedure was performed for each stress and delayed tomographic study. Percent washout circumferential profiles were then calculated as the stress profile minus the delayed profile, multiplied by 100 over the stress profile, using the profiles of the corresponding anatomic cuts at times of stress and delayed tomography respectively. The bull’s-eye map for percent washout was then generated. The washout image was divided into 4 regions of 90 degrees each (anterior, septal, inferior, and lateral), as shown in Fig. 1. Washout rates within a 90-degree arc of the anterior...
Thallium Washout Rate after Dipyridamole

A. Stress

B. Delayed

C. Stress  D. Delayed

E. Washout

Fig. 4. Representative short-axis slices of stress (A) and 3-h delayed (B) images of a patient with single stenosis of the left anterior descending artery. Bull's-eye stress (C), delayed (D) and washout (E) images in the same patient. Both studies demonstrate a reversible perfusion defect in the anterior, septal and apical regions. The mean washout rate in the anterior region of this patient was 9%.

Fig. 5. Average thallium washout rate in the anterior region of the left ventricle in 16 control patients and 31 patients with coronary artery disease (CAD).

Results

Hemodynamic and Myocardial Metabolic Responses to Intravenous Dipyridamole

Table I lists numerical data for the hemodynamic and myocardial metabolic responses to the infusion of dipyridamole during the catheterization study in the 16 control patients and the 31 CAD patients. After dipyridamole infusion, heart rate increased slightly, systolic blood pressure decreased slightly, and rate-pressure product increased slightly in both the control group and the CAD group. Heart rate, systolic blood pressure and rate-pressure product at baseline and after dipyridamole were not significantly different between the two groups.

There was no difference in great cardiac vein flow at baseline between the two groups. However, after dipyridamole, great cardiac vein flow was significantly lower in the CAD group than in the control group (148±55 vs 228±84 ml/min, p<0.001) (Fig. 2). Coronary flow reserve, defined as the percent change in great cardiac vein flow from baseline, was also significantly lower in the CAD group than in the control group (128±82 vs 242±89%, p<0.001) (Fig. 2). After dipyridamole, a decrease in coronary arteriovenous oxygen difference (associated

Statistical Analysis

All group data are reported as mean ± SD. Variables at baseline and after dipyridamole infusion were compared using a paired Student's t test. Group comparisons were performed by the unpaired Student's t test. Relationships between variables were tested by simple linear regression. A p value < 0.05 was considered significant.
with an increase in coronary blood flow) was observed in both groups. Coronary arteriovenous oxygen difference after dipyridamole was significantly higher (p<0.05) in the CAD group than in the control group, reflecting lower coronary blood flow in the CAD group. After dipyridamole, myocardial oxygen consumption, which is the product of great cardiac vein flow and coronary arteriovenous oxygen difference, increased slightly but significantly (p<0.05) in the control group, but was unchanged in the CAD group. There was no significant difference in myocardial oxygen consumption at baseline or after dipyridamole between the two groups. There was also no difference in myocardial lactate extraction rate at baseline between the two groups. After dipyridamole, myocardial lactate production, which is metabolic evidence of myocardial ischemia, was observed in 14 of the 31 patients with CAD, compared with only 1 of the 16 control patients. Myocardial lactate extraction rate after dipyridamole was significantly lower in the CAD group than in the control group (-2±20 vs 10±10%, p<0.05) (Fig. 3).

Dipyridamole Thallium-201 Scintigraphy

Fig. 4 shows an example of dipyridamole 201TI scintigraphy in a patient with CAD. All of the control patients had normal images whereas 28 of the 31 patients with CAD had a reversible defect in the anterior region of the left ventricle. The remaining 3 patients with CAD had normal images. The average 201TI washout rate in the anterior region of the left ventricle was significantly lower in the CAD group than in the control group (21±17 vs 43±10%, p<0.001) (Fig. 5).

Relation of Coronary Hemodynamics and Myocardial Metabolism to Washout Rate

The relation of the coronary flow reserve and myocardial lactate extraction rate after dipyridamole to the thallium washout rate in all 47 patients is shown in Fig. 6. There was a significant correlation between the washout rate and coronary flow reserve (r=0.50, p<0.001), and also between the washout rate and the lactate extraction rate (r=0.41, p<0.01), although a wide variation was noted. In addition, there was a significant correlation between the coronary flow reserve and the lactate extraction rate (r=0.45, p<0.01).

Chest Pain and ST Segment Depression after Dipyridamole Infusion

After dipyridamole infusion, chest pain occurred in 15 patients (1 control patient and 14 CAD patients) during the scintigraphy study and in 18 patients (2 control patients and 16 CAD patients) during the catheterization study. Fourteen patients (1 control patient and 13 CAD patients) had chest pain during both the scintigraphy study and the catheterization study. The 14 CAD patients who experienced chest pain during
TABLE II  WASHOUT RATE, CORONARY FLOW RESERVE AND LACTATE EXTRACTION RATE IN CAD PATIENTS WITH AND WITHOUT DIPYRIDAMOLE-INDUCED CHEST PAIN

<table>
<thead>
<tr>
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<th>WR (%)</th>
<th>CFR (%)</th>
<th>LER (%)</th>
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<tr>
<td><strong>CAD patients with chest pain</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>14±20‡</td>
<td>97±71‡</td>
<td>−13±21§</td>
</tr>
<tr>
<td>(n=14*)</td>
<td>(n=16†)</td>
<td>(n=16†)</td>
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</tr>
<tr>
<td><strong>CAD patients without chest pain</strong></td>
<td>27±12</td>
<td>162±82</td>
<td>11±9</td>
</tr>
<tr>
<td>(n=17*)</td>
<td>(n=15†)</td>
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<td>(n=15†)</td>
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CAD = coronary artery disease; WR = washout rate of thallium-201; CFR = coronary flow reserve; LER = lactate extraction rate after dipyridamole infusion. Values are mean ± SD.
With or without chest pain *during scintigraphy study; †during catheterization study.
‡p<0.05; §p<0.001 vs CAD patients without chest pain.

TABLE III  WASHOUT RATE, CORONARY FLOW RESERVE AND LACTATE EXTRACTION RATE IN CAD PATIENTS WITH AND WITHOUT DIPYRIDAMOLE-INDUCED ST DEPRESSION

<table>
<thead>
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<th>WR (%)</th>
<th>CFR (%)</th>
<th>LER (%)</th>
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<tr>
<td><strong>CAD patients with ST depression</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>14±20‡</td>
<td>105±79‡</td>
<td>−8±21§</td>
</tr>
<tr>
<td>(n=16*)</td>
<td>(n=20†)</td>
<td>(n=20†)</td>
<td></td>
</tr>
<tr>
<td><strong>CAD patients without ST depression</strong></td>
<td>29±8</td>
<td>170±73</td>
<td>11±10</td>
</tr>
<tr>
<td>(n=15*)</td>
<td>(n=11†)</td>
<td></td>
<td>(n=11†)</td>
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</table>

Abbreviations as in Table II. Values are mean ± SD.
With or without ST depression *during scintigraphy study; †during catheterization study.
‡p<0.05; §p<0.01 vs CAD patients without ST depression.

the scintigraphy study demonstrated significantly lower washout rates than did the 17 CAD patients who had no chest pain (Table II). The 16 CAD patients with chest pain during the catheterization study demonstrated lower coronary flow reserves and lower lactate extraction rates after dipyridamole than did the 15 CAD patients without chest pain (Table II).

Dipyridamole-induced ischemic ST segment depression occurred in 18 patients (2 control patients and 16 CAD patients) during the scintigraphy study and in 22 patients (2 control patients and 20 CAD patients) during the catheterization study. The 18 patients with ST depression during the scintigraphy study also had ST depression during the catheterization study. The 16 CAD patients who had ST depression during the scintigraphy study demonstrated significantly lower washout rates than did the 15 CAD patients who had no ST depression (Table III). The 20 CAD patients with ST depression during the catheterization study demonstrated lower coronary flow reserves and lower lactate extraction rates after dipyridamole than did the 11 CAD patients without ST depression (Table III). Aminophylline was administered to 3 patients with CAD to relieve chest pain during the scintigraphy study. None of the patients received aminophylline before the completion of the catheterization study.

DISCUSSION

Thallium-201 Washout Rate and Coronary Blood Flow

In a canine model, intravenous dipyridamole increases coronary blood flow in regions served by normal coronary vessels, but not in myocardial regions served by diseased vessels, thus producing an inhomogeneity of blood flow that would be evident by 201Tl scintigraphy. In the normal zone, the increase in coronary blood
flow with the same dose of dipyridamole as that used in our study ranges from 2.5 to 4.5 times the baseline value in experimental studies\textsuperscript{16,17,26} and from 2.1 to 3.8 times the baseline value in clinical studies\textsuperscript{27–32}. In our study, the increase in coronary blood flow with dipyridamole was 3.4 times the baseline value in the control patients (as in other studies\textsuperscript{16,17,26–32}). In the patients with CAD, the increase in coronary blood flow was 2.3 times the baseline value (lower than in the control patients). The findings in dipyridamole \textsuperscript{203}Tl scintigraphy were different between the two groups (corresponding to the difference in coronary blood flow). Most patients with CAD (28/31, 90\%) had an initial defect that represented the relative myocardial hypoperfusion in the distribution of the stenosed vessel during stress, while all of the control patients had normal images. The average \textsuperscript{203}Tl washout rate in the area corresponding to that drained by the great cardiac vein was lower in patients with CAD than in control patients. As a result of the lower washout rates, the initial defects observed in the 28 patients with CAD were normalized on the delayed images. The results of our clinical study are consistent with those of other experimental studies\textsuperscript{13–16}. They show that dipyridamole-induced vasodilation in the presence of a coronary stenosis results in reduced coronary blood flow, diminished thallium uptake and delayed clearance (compared with increased coronary blood flow, increased uptake and more rapid clearance in normally perfused myocardium), which produce an initial defect with delayed redistribution\textsuperscript{13–16}.

The washout rate (the percent change in thallium activity between initial and delayed imaging) is used to quantify the extent of redistribution. The primary determinant of the washout rate is the level of initial thallium uptake, which, in turn, is proportional to myocardial blood flow\textsuperscript{12,13,19–21}. After its flow-related distribution, thallium redistributes within the body, depending on the gradient of thallium levels between the tissue and the blood. In patients with CAD, coronary blood flow and corresponding initial thallium uptake are lower than those in patients without CAD. A decrease in initial thallium uptake leads to a lower concentration gradient between the myocardium and the blood, which reduces the washout rate. Therefore, the washout rate is expected to reflect, indirectly, coronary hemodynamics at the time of the thallium injection. In a canine model, Okada et al\textsuperscript{12} demonstrated that the washout rate after dipyridamole infusion was correlated with the hemodynamic severity of coronary stenosis as assessed by the extent of the reduction in the hyperemic response after a brief coronary occlusion. In our study, the washout rate showed a significant correlation (r=0.50, p<0.001) with coronary flow reserve in all of the patients (Fig. 6). This suggests that the washout rate reflects the hemodynamic severity of the coronary stenosis in humans.

**Dipyridamole-Induced Myocardial Ischemia**

In the present study, dipyridamole-induced ST segment depression (electrocardiographic evidence of ischemia) occurred in 20 (65\%) of the 31 patients with CAD during the catheterization study. Dipyridamole-induced myocardial lactate production (metabolic evidence of myocardial ischemia) occurred in 14 (45\%) of the 31 patients with CAD. In previous studies, dipyridamole-induced ST depression occurred in 3 to 35\% of the patients studied\textsuperscript{5,8,33–38} and in 14 to 61\% of the patients with angiographically documented CAD\textsuperscript{5,36–40}. In patients with CAD without myocardial infarction, the incidence of ST depression was as high as 63\%\textsuperscript{38} (similar to the results in our study) and even 84\%\textsuperscript{40}. Myocardial ischemia results from an imbalance between myocardial oxygen supply and demand. In the present study, the increase in rate-pressure product after dipyridamole infusion was only 10\% and that in myocardial oxygen consumption was only 16\% in all of the patients. Therefore, the increase in myocardial oxygen demand cannot, by itself, account for the dipyridamole-induced ischemia. In the present study, intravenous dipyridamole caused an increase in great cardiac vein flow in all of the patients, except 2 patients with CAD who exhibited myocardial lactate production as a result of the decrease in great cardiac vein flow. In 12 patients with CAD, myocardial lactate production was observed after dipyridamole, despite the increase in great cardiac vein flow. Thus, dipyridamole-induced
ischemia seems to occur as a result of reduced regional coronary blood flow caused by a "steal" phenomenon. Dipyridamole increases blood flow in the subepicardium, but not in the subendocardium because the subendocardial vasodilator reserve is already exhausted in the presence of coronary stenosis. Even if total blood flow increases, the net effect is the shunting of blood from the subendocardium to the subepicardium, resulting in myocardial ischemia.

In the present study, the washout rate, the coronary flow reserve and the lactate extraction rate after dipyridamole were lower in CAD patients with dipyridamole-induced ST depression than in CAD patients without ST depression. The washout rate showed a significant correlation (r=0.41, p<0.01) with the lactate extraction rate in all of the patients (Fig. 6). Beller et al demonstrated that dipyridamole-induced myocardial ischemia results in a prolonged intrinsic washout rate in a canine model. It is possible that dipyridamole-induced myocardial ischemia reduced the washout rate in the patients in our study. However, since the lactate extraction rate also correlated with coronary flow reserve in all of the patients (r=0.45, p<0.01), we conclude that these factors contribute to the washout rate individually and in conjunction with each other. Myocardial ischemia was induced as a result of a reduction in the coronary flow reserve, which reduced the washout rate. Thus, our results do not conclusively demonstrate whether the washout rate is reduced by dipyridamole-induced myocardial ischemia independent of the reduction in coronary flow reserve. However, the relationship between the washout rate and both the coronary flow reserve and the lactate extraction rate observed in this study suggest that the washout rate reflects the severity of coronary artery disease, as assessed by both coronary hemodynamics and myocardial metabolism. This confirms the results of other clinical studies which show that washout rate analysis is useful for detecting patients with severe coronary artery disease, such as those with left main coronary artery disease, multivessel disease, or high-grade coronary artery narrowing.

Although dipyridamole-induced ST depression occurred in 65% of the CAD patients in this study, redistribution defects were observed in 9 CAD patients without ST depression. Thallium defects induced by dipyridamole are produced by heterogeneity in coronary blood flow. Therefore, redistribution defects can occur without ischemia.

**Dipyridamole-Induced Chest Pain**

In the present study, dipyridamole-induced chest pain occurred in 2 (13%) of the 16 control patients and in 16 (52%) of the 31 patients with CAD. The CAD patients with chest pain demonstrated lower washout rates, lower coronary flow reserves and lower lactate extraction rates than did the CAD patients without chest pain. In previous studies, dipyridamole-induced chest pain occurred in 18 to 51% of the patients studied. Zhu et al reported that there were no differences between "pain" and "no pain" groups with regard to the incidence, extent, and severity of coronary artery disease. However, that study included patients with myocardial infarction. In CAD patients without myocardial infarction, Takeishi et al demonstrated that the "pain" group's scores for washout abnormalities were significantly greater in extent and severity than those of the "no pain" group. Both that study and our study indicate that, in CAD patients without myocardial infarction, patients with dipyridamole-induced chest pain have more severe coronary artery disease, as assessed by coronary hemodynamics and myocardial metabolism as well as by washout rate analysis, than patients without chest pain.

**Study Limitations**

Gould reported that the ratio of maximal flow in a normal area to that in a stenotic one must be at least 2:1 before defects appear in the myocardial perfusion image of Tl. In our study, the ratio of maximal coronary flow (great cardiac vein flow after dipyridamole infusion) in control patients to that in CAD patients was 1.5:1 (lower than 2:1), while defects were observed in CAD patients. This discrepancy can be attributed to our method of assessing coronary flow using great cardiac vein flow. The great cardiac vein receives blood from the left anterior descending arterial system.
which represents an admixture of venous blood not only from the abnormal area (distal to the coronary stenosis) but also from the normal area (proximal to the coronary stenosis). To compare the washout rate with the great cardiac vein flow, we measured the mean washout rate in the anterior region of the left ventricle (bull’s-eye map) which includes the normal area as well as the abnormal area.

The left anterior descending coronary artery supplies both the anterior free wall and the anterior septum of the left ventricle. Thus, we should investigate the washout rate of the septal region as well as the anterior region. However, the computer program we used to obtain a mean regional washout was only able to examine quarters of the whole bull’s-eye. The 90-degree arc of the septal region includes the inferior septum, which is supplied by the right coronary artery. We had no way to separate this area and therefore did not evaluate the septal region in this study.

Patients with myocardial infarction were excluded from this study. Slow regional thallium washout would be expected in regions of low flow, but faster washout occurs in necrotic areas. Since thallium uptake in infarcted regions depends on the amount of viable myocardium, as well as on coronary blood flow, the washout rate may not reflect coronary hemodynamics. In addition, background subtraction may increase the washout rate in an area of infarction. Therefore, our findings cannot be extrapolated to patients with myocardial infarction.

Conclusions

This study in humans confirms the experimentally documented relation between coronary blood flow and myocardial washout rate of 201Tl after dipyridamole infusion. The relative decrease in coronary blood flow in the distribution of a stenosed vessel results in diminished thallium uptake and delayed clearance. The washout rate correlates with coronary flow reserve. Although this study does not prove that myocardial ischemia reduces the washout rate, a slow washout rate seems to be related to myocardial metabolic, symptomatic and electrocardiographic evidence of ischemia which is induced as a result of a reduction in coronary flow reserve. Therefore, the washout rate seems to reflect the severity of coronary artery disease, as assessed by coronary hemodynamics, myocardial metabolism, symptoms and electrocardiography.

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