Left ventricular (LV) dysfunction and residual ischemia are useful prognostic indicators in acute myocardial infarction (AMI). Successful reperfusion therapy clearly reduces infarct size and prevents left ventricular expansion. Early estimation of infarct size is necessary for predicting the severity of infarction and planning the rehabilitation program. Infarct size is usually determined using creatine kinase (CK) or thallium-201 (201T1) polar map display. But these data are not clinically reliable, because reperfusion therapy causes a ‘washout’ of CK, and 201T1 is not appropriate for determining infarct size.

We devised a new method to estimate infarct size using dual single photon emission computed tomography (dual SPECT) with 201T1 and technetium-99m pyrophosphate (99mTc pyp), and designated the result as %MI. To evaluate the usefulness of %MI as a predictor of LV dysfunction, we investigated the correlations between %MI and other markers of LV dysfunction: peak CK, ejection fraction (EF) and LV asynergy.

**Methods**

**Subjects**

The subjects for this study were 78 AMI patients (61 males and 17 females, aged 37–85 years). Their clinical features are shown in Table 1. All subjects underwent dual SPECT and left ventriculography (LVG) within 4 weeks of onset.

**Dual SPECT**

Dual SPECT with 201T1 and 99mTc pyp was performed at 3–5 days from onset. Three hours after intravenous injection of 740 MBq of 99mTc pyp, 111 MBq of 201T1 was injected. Simultaneous dual SPECT was performed 5 min after injection of 201T1. Thirty-two 30-s projection images were obtained, from 45° right-anterior oblique to 45° left-posterior oblique, using a rotating large field of view gamma camera (GE Starcam 3000) equipped with a low-energy, high resolution, parallel-hole-collimator. The camera was interfaced with a dedicated computer. Each image was obtained at a digital resolution of 64×64. Energy discriminations were set at 75 KeV with a 20% window for 201T1 images, and at 140 KeV with a 15% window for 99mTc images.

**Table 1 Clinical Characteristics of Patients**

<table>
<thead>
<tr>
<th></th>
<th>PTCA (n=36)</th>
<th>PTCR (n=11)</th>
<th>Conservative (n=31)</th>
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<tbody>
<tr>
<td>Age (years)</td>
<td>60.6±9.1</td>
<td>61.7±8.6</td>
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<tr>
<td>Gender (M/F)</td>
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<td>10/1</td>
<td>23/8</td>
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<td>Infarct-related artery</td>
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<td></td>
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<tr>
<td>LAD</td>
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<td>4</td>
<td>10</td>
</tr>
<tr>
<td>RCA</td>
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<td>5</td>
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<tr>
<td>LCx</td>
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<td>2</td>
<td>6</td>
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<tr>
<td>Peak CK (IU/L)</td>
<td>96.6±70.2</td>
<td>85.4±82.1</td>
<td>147.8±91.3</td>
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<td>%MI (%)</td>
<td>17.2±10.9</td>
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<td>Tl-uptake (%)</td>
<td>34.9±15.7</td>
<td>26.9±16.0</td>
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<td>Time to LVG (days)</td>
<td>19.1±3.9</td>
<td>20.4±3.9</td>
<td>23.8±4.4</td>
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<td>EF (%)</td>
<td>63.6±9.3</td>
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<td>53.9±15.9</td>
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Wall motion

<table>
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<th>Hypokinesis</th>
<th>Akinesis</th>
<th>Dyskinesis</th>
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<td>5</td>
<td>2</td>
<td>4</td>
<td>1</td>
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</table>

PTCA, percutaneous transluminal coronary angioplasty; PTCR, percutaneous transluminal coronary reperfusion; LAD, left anterior descending; RCA, right coronary artery; LCx, left circumflex coronary artery; LVG, left ventriculography; EF, ejection fraction.
Orthogonal images were generated by oblique angle reconstruction, producing short-axis (base, middle, apex), vertical long-axis, and horizontal long-axis slices, each 6 mm thick. In this study, we selected 3 short-axis image slices to calculate %MI (Fig 1). All images were analyzed using the circumferential profile method.

Calculation of %MI

Fig 1 shows the 201T1 circumferential profile curve and the 99mTc pyp count curve for the same slice. The ratio of infarct area to myocardial volume in slice X is designated %MIX. The area enclosed by the accumulation of 99mTc pyp and the circumferential profile curve of 201T1 (area A in blue) was regarded as the infarct area. Fig 1 also shows the formula for calculating %MI. After calculating %MI in each short-axis slice (base, middle, apex), we designated these as %MIB, %MI M and %MI A, respectively. The middle slice means the center of the left ventricle. The basal slice means the most basal slice including septal wall. The apical slice means the most apical slice including left ventricular lumen. The distance from the center point to the maximum count site in slice x (Lx) was also measured in the 3 slices and designated LB, LM and LA respectively. Using %MI and Lx in each slice, %MI of the whole myocardium was calculated using the formula in Fig 2. In the calculation of %MI, the TI defect was thought to be the depth and the Tc-pyp uptake the width of the myocardial infarction.

Correlation of %MI With Other Markers of LV Dysfunction

Serum CK was measured every 3 h following admission. Peak CK corresponds to the maximum count of serum CK obtained. EF was calculated from LVG using Simpson’s method. We investigated the correlation between %MI and these markers. Wall motion of the infarct area was classified as normal, hypokinesis, akinesis or dyskinesis according to the LVG by 2 experienced cardiologists. The mean %MI of these 4 asynergy groups were compared with each other.

Analysis of Data

Data are presented as mean±SD values. Simple linear regression was calculated using the least-squares method for %MI with peak CK and EF. Correlation was tested
New Method of Estimating Infarct Size

Fig 2. Formula for calculation of $\%MI$.

$$%MI = \frac{\pi L_b^2 \times %MIB \times d + \pi L_m^2 \times %MIM \times d + \pi L_a^2 \times %MIA \times d}{\pi L_b^2 \times d + \pi L_m^2 \times d + \pi L_a^2 \times d} \times 100 (%)$$

Fig 3. Correlation between $%MI$ and peak CK.

Fig 4. Correlation between $%MI$ and EF (ejection fraction).
using Pearson’s correlation coefficient. In asynergy analysis, the %MI of each group was analysed using the analysis of variance (ANOVA), and significant differences were determined by the multiple comparison test (Scheff test). Statistical significance was defined as p<0.05.

**Results**

In all patients, %MI was readily calculated. The regression coefficient between %MI (x) and peak CK (y) was y=343.8+41.8x and r=0.731 in percutaneous transluminal coronary angioplasty (PTCA) patients, y=302.8+60.6x and r=0.724 in percutaneous transluminal coronary reperfusion (PTCR) patients, and y=348.9+58.2x and r=0.728 in conservatively treated patients. A statistically significant (p<0.05) correlation was seen in each individual patient, and also for all patients as a whole (y=242.0+47.8x, r=0.729) (Fig 3). The regression coefficient between %MI (x) and EF (y) was y=70.9–0.37x and r=–0.53 in PTCA patients, y=71.4–0.73x and r=–0.63 in PTCR patients, and y=74.9–0.82x and r=–0.68 in conservative patients. A statistically significant (p<0.05) correlation was seen in each individual patient, and also for all patients as a whole (y=73.5–0.68x, r=–0.605) (Fig 4). A statistically significant correlation was seen between %MI and both peak CK and EF irrespective of whether reperfusion therapy was performed. Asynergy analysis showed that %MI for the akinesis group was significantly larger than that of the normal (p<0.01) and hypokinesis (p<0.05) groups (Fig 5).

**Discussion**

Residual ischemia and LV dysfunction determine the patient’s prognosis in cases of AMI. Because prevention of LV dysfunction is the main object of reperfusion therapy, an early estimate of infarct size is desirable. There are several clinical methods of calculating infarct size. Sobel et al. estimated infarct size by washout of CK. However, reperfusion washes out CK sooner, causes it to peak earlier, and decreases the total CK, so following reperfusion therapy CK is not appropriate for estimating infarct size by Sobel’s formula. The same problem exists for CK-MB.

Currently, nuclear imaging methods with 99mTc pyp, Tl-201, and 99mTc isonitrile are used to measure infarct size. With 99mTc pyp, one can demonstrate infarct area, but not whole myocardial volume, so it is impossible to express the ratio of infarct area to myocardial volume. With 201Tl, one can show the severity of myocardial damage and whole myocardium volume. However, because of its poor sensitivity and resolution, 201Tl cannot precisely define the area of infarction. Defining the infarct area with 99mTc pyp and the severity with 201Tl, using dual SPECT with 99mTc pyp and 201Tl we can readily calculate the ratio of infarct area to whole myocardial volume. In cases of recurrent AMI, with 201Tl and 99mTc isonitrile, fresh infarct area cannot be differentiated from old myocardial infarction. Only 99mTc pyp can clearly demonstrate the area of AMI, if dual SPECT is performed within 7 days of onset.

Some clinicians use the 201Tl Bull’s eye imaging polar map to estimate infarct size, but since the Bull’s eye map does not take LV shape into account, it usually underestimates the infarct area at the LV apex. In contrast, in our method, %MI is calculated directly from LV dimensions, and the ratio is therefore more accurate than Bull’s eye imaging.

As is widely known, 99mTc pyp also accumulates in stunned myocardium. The %MI in our method may therefore include both infarct area and area at risk. A new way to differentiate stunned myocardium from infarct area requires further investigation.

**Conclusions**

Our study showed that we can readily calculate infarct size, expressed as %MI, using 99mTc pyp and 201Tl dual SPECT imaging in the early stage of AMI. Good correlation was also showed between %MI and other markers of LV dysfunction. We consider %MI to be useful in predicting the severity of myocardial damage and planning rehabilitation programs, with or without reperfusion therapy, in AMI patients.
References


