Annals of Nuclear Medicine Vol. 15, No. 2, 93–96, 2001

# Twenty-four-hour Tl-201 delayed scan underestimates myocardial viability in patients with acute myocardial infarction after percutaneous transluminal coronary angioplasty

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***Background:*** Myocardial viability in area at risk of acute myocardial infarction (AMI) after reperfusion therapy may be underestimated by the 24-hour images due to reverse redistribution (r-RD).
***Methods:*** Subjects were 37 AMI patients in whom Tc-99m pyrophosphate (PYP)/Tl-201 dual-isotope SPECT was positive. The 24-hour delayed scan was performed with only a Tl window. One month later, follow up rest Tl SPECT was performed to evaluate myocardial viability. In early (at PYP/Tl-201 dual-isotope SPECT), 24-hour, and one month follow up Tl studies, Tl uptake in the area of AMI was scored into four grades: 3 as normal to 0 as severely reduced. The scores were evaluated.
***Results:*** Among the 37 AMI lesions, there were 16 r-RD, 3 RD, 16 fixed defect (FD) and 2 normal (positive PYP and normal Tl). Mean Tl scores were early; $1.4 \pm 1.1$, 24-hr; $0.9 \pm 0.9$ and one month; $1.3 \pm 1.1$. The 24-hour Tl score was lower than the early and one month Tl scores ($p < 0.01$).
***Conclusion:*** Reverse redistribution is frequently observed in an area at risk where PYP SPECT was positive. Nuclear medicine physicians should be aware of the existence of frequent r-RD in Tl scan to avoid the underestimation of myocardial viability in the acute phase after PTCA.

**Key words:** thallium-201, myocardium, viability, reverse redistribution

## INTRODUCTION

NUCLEAR CARDIOLOGY or myocardial perfusion scintigraphy is playing a main role in the assessment of myocardial viability in patients with coronary artery disease.[1–5] To assess myocardial viability, the 24-hour Tl-201 SPECT after intravenous administration at rest is one of the best of the routine nuclear medicine tests, but the viability of the rescued myocardium in patients with acute myocardial infarction (AMI) after reperfusion therapy might be underestimated due to reverse redistribution (r-RD).[6–10] The purpose of this study is to clarify the incidence of r-RD and its clinical implication.

Received September 11, 2000, revision accepted January 9, 2001.

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## MATERIALS AND METHODS

*Subjects*

The subjects were 37 lesions in 37 consecutive patients with AMI (31 males and 6 females) (28 anteroseptal, 7 inferior, 2 lateral wall), who underwent primary reperfusion therapy (percutaneous transluminal coronary angioplasty, PTCA) within 12 hours after onset. All the patients were examined with Tc-99m pyrophosphate (PYP)/Tl-201 dual-isotope SPECT with a 24-hour Tl delayed scan. All of the 37 AMI were diagnosed according to clinical symptoms,

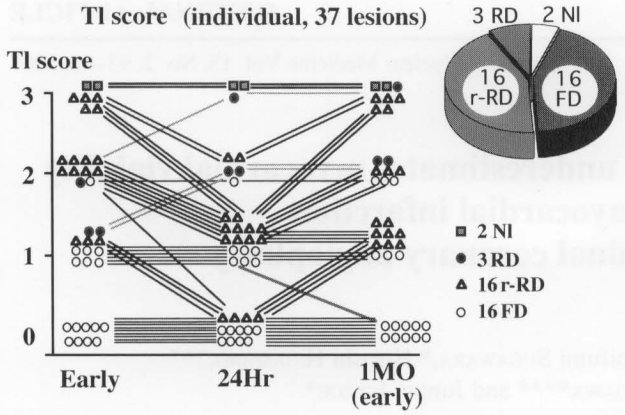


**Fig. 1** Individual Tl-uptake scores of early, 24-hour and one month Tl scans in 37 patients were plotted. Among the 37 AMI lesions, there were 16 r-RD, 16 fixed defects, 3 RD, and 2 normals. Normal lesion means positive PYP with normal Tl perfusion.

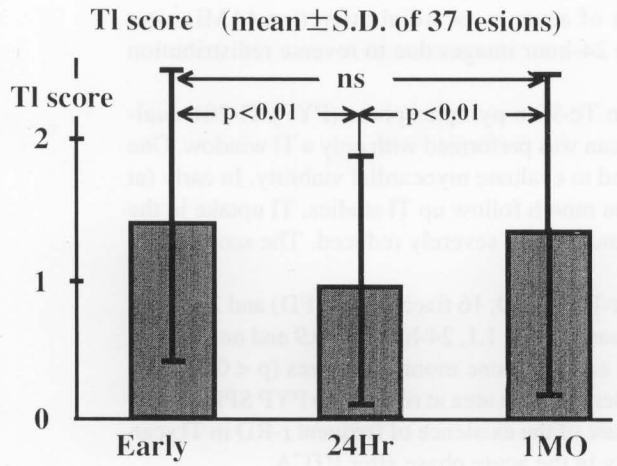


**Fig. 2** Mean Tl-uptake scores on early, 24-hour and one month Tl scans in all the 37 AMI lesions are 1.4 ± 1.1, 0.9 ± 0.9, and 1.3 ± 1.1, respectively. The 24-hour Tl score was significantly lower than those on early and one month Tl scores ($p < 0.01$).

ECG changes, increase in creatinine kinase-MB, and positive Tc-99m PYP/Tl-201 dual-isotope SPECT.

*Study Protocol*

The PYP/Tl dual-isotope SPECT was performed within a week (4.2 ± 1.8 days) after direct PTCA. The 24-hour delayed scan was performed on the day after the PYP/Tl dual-isotope SPECT. After one month, follow up Tl SPECT was performed to evaluate myocardial viability. The SPECT system used was a 3-head camera with low energy high resolution collimators (GCA-9300A, Toshiba, Inc., Tokyo, Japan) and an image processor (GMS-550u, Toshiba, Inc., Tokyo, Japan).

*$^{99m}$Tc-PYP/$^{201}$Tl Dual Isotope SPECT*

Tc-99m pyrophosphate (370 MBq) was injected intravenously. Two hours later, Tl-201 (111 MBq) was injected intravenously during the resting condition. Fifteen minutes after the injection, the data were acquired with a dual-isotope mode. Photopeaks were 71 keV for Tl-201 and 140 keV for Tc-99m both with a 20% window. The data acquisition parameters were 30 sec/step in 20 steps × 3 detectors (10 min, 60 steps in total). The matrix was 64 × 64 and the zooming factor was 1.5. Transaxial slices were reconstructed by filtered back-projection with a Butterworth filter (order = 8, 0.15 cycle/pixel). Transaxial images were reoriented to short and long cardiac axes.

*$^{201}$Tl 24-hour Delayed Scan*

On the day after the PYP/Tl dual-isotope SPECT, the 24-hour delayed scan was performed with only a Tl window. The parameters for acquisition and reconstruction were the same as for the dual-isotope SPECT, except that a 45 sec/step for acquisition was used.

*$^{201}$Tl one month Scan*

Fifteen minutes after intravenous injection of Tl-201 (111 MBq) at rest, data were acquired. The parameters for acquisition and reconstruction were the same as for the dual-isotope SPECT.

*Data Analysis*

Tl-uptake of the AMI lesions was scored and classified into four grades by agreement between two experienced nuclear medicine physicians: 3 as normal, 2 as mildly reduced, 1 as moderately reduced, and 0 as severely reduced. To simplify the analyses, we evaluated the scores of the risk area, where PYP was positive (normal perfusion area was not evaluated).

The individual courses of the Tl-uptake score in 37 patients were plotted to clarify the incidences of r-RD, RD, and fixed defect. An area of Tl-uptake 1 or more after one month follow up study was judged as viable (Tl-uptake = 0 was judged as non-viable).

Mean Tl-uptake scores on early Tl scan, 24-hour Tl scan, and one month Tl scan, were compared.

*Statistical Analysis*

Values were expressed as the mean ± SD. Statistical comparison of difference in the mean Tl-uptake scores on early Tl, 24-hour Tl and one month Tl scans was performed with ANOVA. A probability value of $< 0.05$ was considered statistically significant.

## RESULTS

Individual Tl-uptake scores on early, 24-hour and one month Tl scans in 37 patients were plotted (Fig. 1). Among the 37 AMI lesions, there were 16 r-RD, 16 fixed defects, 3 RD, and 2 normals (normal: positive PYP with

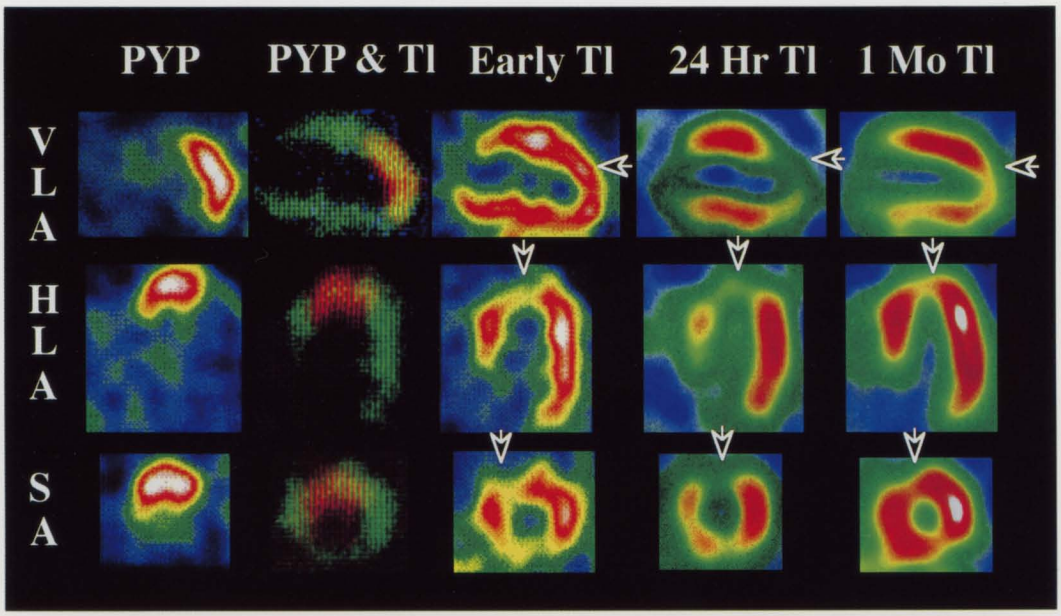


**Fig. 3** A representative 65-year-old male patient with anterior acute myocardial infarction. The left column is Tc-99m pyrophosphate (PYP), the second column is an image fusion of PYP and Tl, the third column is early Tl image at dual-isotope SPECT, the fourth column is 24-hour Tl image, and the right column is one month Tl image. There is a PYP accumulation in the anterior wall, where early Tl image depicts normal lower limit perfusion. The 24-hour delayed scan depicts decreased Tl perfusion compared to early image (r-RD). Tl perfusion came back in 1 month follow up study. (VLA; vertical long axial images, HLA; horizontal long axial images, SA; short axial images)

normal Tl perfusion). In the 28 anteroseptal AMI lesions, there were 14 r-RD, 10 fixed defects, 2 RD and 2 normals. In 7 inferior AMI lesions, there were 2 r-RD and 5 fixed defects. One of the two lateral AMI lesions was a fixed defect and the other was RD. Tl-uptake scores in all 16 r-RD patients were 1 or more on 1 month follow up study, so that all lesions were judged viable. Among the 16 r-RD lesions, 12 lesions showed an increase in the Tl score on 1 month follow up.

Mean Tl-uptake scores on early, 24-hour and one month Tl scans in all the 37 AMI lesions are shown (Fig. 2). Mean Tl scores were $1.4 \pm 1.1$ in early dual SPECT imaging, $0.9 \pm 0.9$ in a 24-hour delayed scan and $1.3 \pm 1.1$ in a one-month Tl follow up study. The 24-hour Tl score was significantly lower than those of early and one month Tl scores ($p < 0.01$, respectively).

A representative case of r-RD is shown (Fig. 3).

## DISCUSSION

Our results showed that r-RD is often observed (16/37 = 43%) in patients with AMI after PTCA. When the patients with an initial Tl-uptake of 0 are excluded, the incidence of the r-RD goes up to 57% (16/28). Our results are comparable to those previously reported with delayed imaging several hours after intravenous injection of Tl-201; 75% (50/67) by Weiss et al.,[6] 49% (18/37) by Umamoto et al.,[7] and 68% (15/22) by Takeishi et al.[9] All of the 16 r-RD lesions were viable according to our interpretation criteria of viability (1 month Tl-score $\geq 1$). Therefore, when a delayed scan rather than an early image is used for the assessment of viability in the acute phase after reperfusion therapy, myocardial viability will be significantly underestimated. Weiss et al.[6] proposed two likely mechanism for faster washout of Tl-201 (r-RD): (a) higher blood flow to the non-infarcted myocardium in the reperfused zone and (b) initial Tl uptake by the necrotic tissue or the interstitial component in the reperfused zone and subsequent faster washout.

The r-RD phenomenon is also reported with Tc-99m MIBI. Takeishi et al.[9] reported that the r-RD was observed in 15 out of 22 (68%) patients after successful primary reperfusion therapy for AMI. The high incidences of r-RD were observed in patients with AMI after reperfusion therapy. Thus the r-RD is a phenomenon, which can be observed in rescued AMI lesions, where myocardial perfusion is reserved and viable.

In this study, all of the 7 AMI lesions with an early Tl-uptake score of 3 had a Tl-uptake score of 3 in a one-month follow up study. All of the 9 patients with an initial Tl-uptake score of 0 continued to be 0 in 24-hour and one month Tl scans. Therefore, when the AMI lesion has no Tl accumulation in the early image after revascularization, regional viability, or recovery of perfusion and function cannot be expected. The results indicate that good accumulation on the "early image" is a predictor of maintained

myocardial perfusion and presumably better function. In recent literature on r-RD with Tl-201, Faraggi et al.[10] concluded that early post injection scans are relevant for assessing myocardial salvage and wall motion recovery.

It is possible that cross talk of Tc-99m to Tl-201 window may affect the early Tl score in the AMI lesion, i.e., the early Tl score may have been overestimated. We believe the effect of the cross talk was minimal or negligible in our visual Tl scoring when our protocol was used (Tc-PYP: 370 MBq, Tl-201: 111 MBq, 20% window), since there were 9 AMI lesions with an early Tl score of 0, in which cases Tc-PYP was apparently positive. Cross talk of Tl-201 to Tc-99m window also seemed negligible for visual interpretation, since the PYP accumulation was clearly localized.

In conclusion, the r-RD is often observed (16/37 = 43%) in area at risk, where PYP SPECT is positive. The area of r-RD was viable. We should be aware of the frequent r-RD phenomenon observed in Tl scans to avoid underestimation of the viability in AMI patients after reperfusion therapy.

## ACKNOWLEDGMENTS

We acknowledge the clinical cooperation in patient management of the cardiologists in the Department of Cardiology and technical assistance of the nuclear medicine technologists in Ehime Imabari Hospital.

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