

Dual radionuclide single-photon emission computed tomography in the prediction of further ischemic risk after acute myocardial infarction

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To evaluate whether the findings of dual single-photon emission computed tomography (SPECT) with technetium-99m pyrophosphate (Tc-99m PPI) and thallium-201 were predictive of further cardiac events in their hospital course, we studied 130 patients recovering from acute myocardial infarction (AMI). Fifty-four patients showed overlapping of Tc-99m PPI and thallium-201 in the same location (overlap positive group), and 76 patients had no overlap (overlap negative group). Of the 130 patients, 36 (28%) had a cardiac event. In patients in the overlap positive group, the incidence of subsequent events was significantly higher than in patients in the overlap negative group (44% versus 16%; $p < 0.001$). In the overlap positive group, the Tc-99m PPI uptake score and the number of overlap segments in patients with further events was significantly higher than those in patients without further events (10.2 ± 5.1 versus 6.4 ± 4.1 , $p < 0.005$ and 5.2 ± 2.0 versus 3.3 ± 1.3 , $p < 0.001$, respectively). These results suggest that patients who have a Tc-99m PPI and thallium-201 overlap negative scan can be candidates for early hospital discharge. In contrast, patients who have a greater number of overlap segments may require early catheterization and revascularization, so that simultaneous SPECT imaging Tc-99m PPI and thallium-201 might be useful for identifying patients with further ischemic risk after AMI in their hospital course.

Key words: technetium-99m pyrophosphate/thallium-201 scintigraphy, cardiac events, acute myocardial infarction, overlap

INTRODUCTION

IT HAS BEEN PROPOSED that selected patients with uncomplicated acute myocardial infarction (AMI) should be discharged early.¹ Early hospital discharge and earlier return to work would lead to an economic advantage. In order to select carefully candidates for early discharge, it is important to identify patients at high risk for further events early in their hospital course.

Several investigators have indicated the benefit of

predischarge exercise test to identify patients at increased risk for further cardiac events,²⁻⁶ but a significant number of patients cannot perform an early exercise test after AMI for various reasons.^{7,8}

It is well known that dual single-photon emission computed tomography (SPECT) by simultaneous imaging with technetium-99m pyrophosphate (Tc-99m PPI) and thallium-201 improves accuracy in detecting Tc-99m PPI accumulation and in assessing the infarcted area semi-quantitatively.⁹⁻¹¹ Tc-99m PPI and thallium-201 overlap on dual SPECT might reflect the presence of salvaged and residual ischemic myocardium adjacent to the necrotic tissue. The aim of this study was to correlate the findings of dual SPECT with Tc-99m PPI and thallium-201 in patients recovering from AMI with further cardiac

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events in their hospital course.

METHODS

Patient population: Between July, 1990 and December, 1997, 130 patients who underwent dual SPECT with Tc-99m PPI and thallium-201 at the Fujieda Municipal Hospital with a diagnosis of acute myocardial infarction were considered for inclusion in this study. All the patients fulfilled the following criteria for a documented AMI: (1) a clinical presentation of chest pain consistent with myocardial ischemia that lasted at least 30 minutes; (2) a typical rise and fall in the serum enzyme level that was consistent with myocardial necrosis, specifically including an increase in creatine kinase; and (3) the appearance of new Q waves or evolutionary ST-T-wave changes on the electrocardiogram.

Coronary angiography: One hundred and ten patients underwent catheterization either during the admission for AMI or within 6 weeks of the event. Early catheterization (within 6 hours after the onset of chest pain) was performed in 80 patients. When occlusion of the coronary artery was confirmed, emergent coronary interventions, intracoronary thrombolytic therapy or percutaneous transluminal coronary angioplasty, or both, were performed.

Dual SPECT imaging and analysis: Each patient underwent dual SPECT 1 to 5 days (mean 2.4 ± 0.6) after the onset of AMI. Twenty mCi (740 MBq) of Tc-99m PPI was injected intravenously and then 3 or 4 mCi (111 or 148 MBq) of thallium-201 was injected 3 hours later. Myocardial imaging with dual SPECT was started 5 minutes after the injection of thallium-201. SPECT was performed with a rotating large-field-of-view gamma camera with a low-energy, high-resolution, parallel-hole collimator (Starcam 400AC/T, General Electric, Milwaukee, USA). A total of 32 projection images were obtained over a 180° arc, from the 45° left posterior oblique to the 45° right anterior oblique position, and for 30 seconds/image. Projection images were recorded as 64×64 matrices with a dedicated nuclear computer system (STARCAM). The camera's energy discriminator was set for the 72 keV photopeak of thallium-201 and the 140 keV photopeak of Tc-99m PPI, respectively, with a 20% window. Short-axis, vertical long-axis and horizontal long-axis tomograms were reconstructed without using attenuation correction.

For visual analysis, the left ventricular myocardium was divided into 16 segments (Fig. 1). Tc-99m PPI uptake and thallium-201 defects were qualitatively analyzed by means of a 4-point grading system (3 = intense, 2 = moderate, 1 = mild, 0 = faint uptake or absent in Tc-99m PPI uptake; 3 = normal, 2 = mild, 1 = moderate reduction, 0 = absent in thallium-201 uptake). Regions of uptake of both Tc-99m PPI (grade; 3, 2 or 1) and thallium-201 (grade; 3, 2 or 1) in the same location were classified as

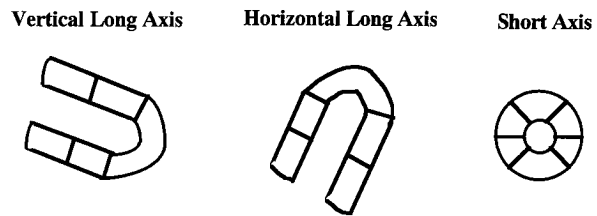


Fig. 1 Midventricular slice from three orthogonal projections.

Table 1 Summary of clinical data for patients with or without cardiac events

	Event group (n = 36)	Nonevent group (n = 94)	p Value
Age (yr)	59 ± 10	61 ± 8	NS
Sex (males)	23 (64%)	66 (70%)	NS
Previous MI	6 (17%)	14 (15%)	NS
Location of acute MI			
Anterior	17 (47%)	40 (43%)	NS
Inferior	14 (39%)	38 (40%)	NS
Lateral	5 (14%)	16 (17%)	NS
Non-Q wave MI	6 (17%)	18 (19%)	NS
Successful reperfusion	18 (50%)	44 (47%)	NS

Table 2 The incidence of cardiac events based on dual SPECT findings

	Overlap positive group (n = 54)	Overlap negative group (n = 76)	Total patients (n = 130)
Total events	24 (44%)	12 (16%)	36 (28%)
Dilated MI	2 (4%)	2 (3%)	4 (3%)
Positive stress test	8 (15%)	6 (8%)	14 (11%)
Recurrent angina	14 (26%)	4 (5%)	18 (14%)

overlap positive; and no region of uptake of both Tc-99m PPI and thallium-201 in the same location was classified as overlap negative. All dual SPECT images from each patient were examined by two independent, experienced observers without knowledge of the patient's identity, clinical data, or the results of coronary angiography.

Scan patterns were correlated with subsequent ischemic events defined as infarct extension, positive predischarge exercise stress test or recurrent angina in hospital or after discharge within 6 weeks after AMI. In the overlap positive group, the number of overlap segments and the Tc-99m PPI uptake score in overlapping segments were also correlated with subsequent ischemic events.

Statistical analysis: All data are expressed as the mean \pm SD. Comparisons of clinical data for patients with or without cardiac events were performed by chi-square test. Student's t-test was used to analyze dual SPECT findings. A p value of < 0.05 was considered statistically significant.

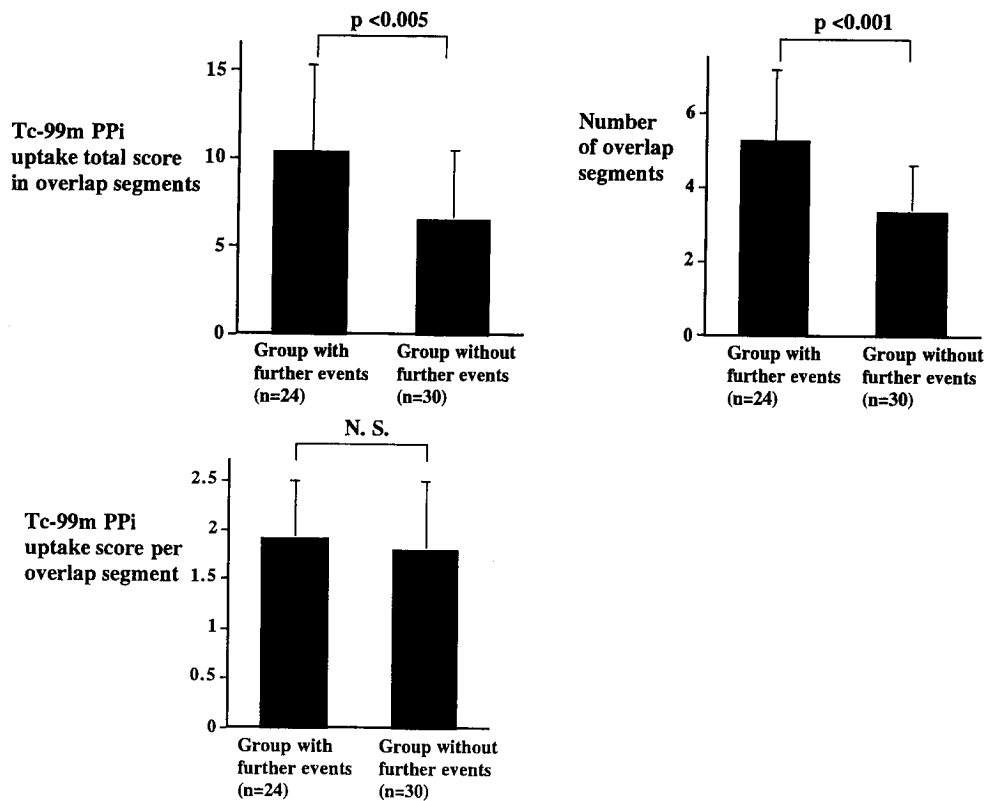


Fig. 2 Technetium-99m pyrophosphate (Tc-99m PPI) uptake total score in overlap segments, the number of overlap segments, and Tc-99m PPI uptake score per segment in overlap positive groups with or without an ischemic event.

RESULTS

The patient group consisted of 89 men and 41 women (mean age 60.9 ± 9.1 yr). Twenty patients had a history of previous infarction. Fifty-seven patients had anterior, 52 had inferior and 21 had lateral myocardial infarction. Sixty-two patients showed signs of successful reperfusion.

Dual SPECT: Fifty-four patients had overlapping of Tc-99m PPI and thallium-201 in the same location (overlap positive group). Seventy-six patients had no region of uptake of both Tc-99m PPI and thallium-201 in the same location (overlap negative group). In ten patients, thallium-201 SPECT showed no defect. Three patients with a small non-Q wave infarction had false-negative Tc-99m PPI SPECT. In the overlap positive group, the Tc-99m PPI uptake total score in overlapping segments was 8.2 ± 4.9 , the number of overlap segments was 4.2 ± 1.9 , and Tc-99m PPI uptake score per overlap segment was 1.9 ± 0.6 .

Correlation with Ischemic Events: Of the 130 patients, 36 (28%) had a cardiac event. There were 4 patients with infarct extension, 14 with positive predischarge exercise stress test, and 18 with recurrent angina in hospital or after discharge within 6 weeks after AMI.

Table 1 is a summary of clinical data for patients with or without cardiac events. There were no significant differences in the age, sex, prevalence of prior myocardial

infarction, type of infarction or the incidence of successful reperfusion.

Table 2 shows the incidence of cardiac events based on dual SPECT findings. Of the 76 patients in the overlap negative group, only twelve (16%) had a cardiac event. In contrast, the incidence of subsequent events was significantly higher in patients in the overlap positive group (24/54, 44%; $p < 0.001$).

Tc-99m PPI uptake total score, the number of overlap segments, and uptake score per segment were compared with the occurrence of further events in the overlap positive group (Fig. 2). In patients with further events, Tc-99m PPI uptake total score and the number of overlap segments were significantly higher than in patients without further events (10.2 ± 5.1 versus 6.4 ± 4.1 , $p < 0.005$ and 5.2 ± 2.0 versus 3.3 ± 1.3 , $p < 0.001$, respectively), but there was no significant difference in the uptake score per segment (1.9 ± 0.6 versus 1.8 ± 0.7 , $p = \text{N.S.}$).

DISCUSSION

Various tests, including exercise and intravenous dipyridamole thallium scintigraphy after AMI, have been reported to identify patients at increased risk for further cardiac events.^{5,6,12-14} These methods are useful and relatively safe in predicting subsequent cardiac events. Younis

et al. studied by means of intravenous dipyridamole thallium scintigraphy in 77 patients recovering from an acute coronary event.¹² They reported that a reversible thallium defect was a significant predictor of a cardiac event, but side effects occurred in 37% of the patients. Turner et al. studied by means of exercise thallium imagings after AMI in 32 patients.¹³ No complications were associated with exercise testing, but exercise thallium imagings were performed 3 weeks after AMI. Topol et al. performed stress thallium imagings 72 hours after AMI in 53 patients.¹⁴ Thirty-six patients showed fixed perfusion defects without redistribution and none of these patients had further in-hospital cardiac events. Many patients are not stable enough for stress testing at 72 hours from the onset of AMI, so that a significant number of patients cannot undergo an early exercise or intravenous dipyridamole thallium scintigraphy after AMI.

Compared with exercise or intravenous dipyridamole thallium imaging, it is particularly important for patients in the immediate postinfarction period that dual SPECT imaging involves only a single-imaging procedure at rest. The other advantage is the detection of Tc-99m PPI and thallium-201 overlap in the same myocardial regions, possibly the presence of living perfused but ischemic myocardium adjacent to the necrotic tissue. Johnson et al. performed simultaneous dual thallium-201 and indium 111-labeled antimyosin monoclonal antibody SPECT imaging in 42 patients with AMI.¹⁵ They found that dual SPECT revealed three patterns of uptake, that is, matches (exactly corresponding thallium defect and antimyosin uptake), mismatches (thallium defect greater than antimyosin uptake) and overlapping thallium and antimyosin in the same segment. They demonstrated that the patients with matches had benign in-hospital courses, and that the patients with mismatches or overlapping had a high incidence of recurrent ischemia.

It is important to early identify patients who will have stable in-hospital courses. This study showed that the incidence of subsequent events was significantly higher in patients in the overlap positive group than in patients in the overlap negative group (44% versus 16%; $p < 0.001$). This result is in agreement with the report of Johnson et al., which suggested that a high percentage (4/5) in the overlapping group went on to have further ischemic events.¹⁵ Patients in the overlap positive group cannot be candidates for early hospital discharge.

In the overlap positive group, the Tc-99m PPI uptake total score and the number of overlap segments in patients with further events were significantly higher than those in patients without further events, but there was no significant difference in the uptake score per segment. It has been suggested that Tc-99m PPI and thallium-201 overlap on dual SPECT might reflect the presence of residual ischemic myocardium adjacent to the necrotic tissue.⁹ Several investigators have reported that patients with subsequent events had a greater number of scan segments

with redistribution than patients without events.^{5,16} The incidence of subsequent events after AMI is therefore dependent on the amount of remaining ischemic myocardium. Our results suggested that the size of ischemically injured myocardium, as reflected by the number of overlap segments, is a significant predictor, and that the extent of Tc-99m PPI uptake is not related to the incidence of further events.

We found that the findings of dual SPECT with Tc-99m PPI and thallium-201 in patients recovering from AMI were predictive of further cardiac events in their hospital course. Patients who have a Tc-99m PPI and thallium-201 overlap negative scan are a low risk group and can be candidates for early hospital discharge. In contrast, patients who have a greater number of overlap segments may require early catheterization and revascularization. The major advantage of dual SPECT is that even patients in the immediate postinfarction period can undergo this test safely. We suggested that simultaneous dual Tc-99m PPI and thallium-201 SPECT imaging might be useful for identifying patients with further ischemic risk.

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