

Impaired Coronary Flow Reserve Is the Most Important Marker of Viable Myocardium in the Myocardial Segment-Based Analysis of Dual-Isotope Gated Myocardial Perfusion Single-Photon Emission Computed Tomography

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Objective: The aim of this study was to investigate the most robust predictor of myocardial viability among stress/rest reversibility (coronary flow reserve [CFR] impairment), ²⁰¹Tl perfusion status at rest, ²⁰¹Tl 24 hours redistribution and systolic wall thickening of ^{99m}Tc-methoxyisobutylisonitrile using a dual isotope gated myocardial perfusion single-photon emission computed tomography (SPECT) in patients with coronary artery disease (CAD) who were re-vascularized with a coronary artery bypass graft (CABG) surgery.

Materials and Methods: A total of 39 patients with CAD was enrolled (34 men and 5 women), aged between 36 and 72 years (mean 58 ± 8 standard in years) who underwent both pre- and 3 months post-CABG myocardial SPECT. We analyzed 17 myocardial segments per patient. Perfusion status and wall motion were semi-quantitatively evaluated using a 4-point grading system. Viable myocardium was defined as dysfunctional myocardium which showed wall motion improvement after CABG.

Results: The left ventricular ejection fraction (LVEF) significantly increased from 37.8 ± 9.0% to 45.5 ± 12.3% ($p < 0.001$) in 22 patients who had a pre-CABG LVEF lower than 50%. Among 590 myocardial segments in the re-vascularized area, 115 showed abnormal wall motion before CABG and 73.9% (85 of 115) had wall motion improvement after CABG. In the univariate analysis ($n = 115$ segments), stress/rest reversibility ($p < 0.001$) and ²⁰¹Tl rest perfusion status ($p = 0.024$) were significant predictors of wall motion improvement. However, in multiple logistic regression analysis, stress/rest reversibility alone was a significant predictor for post-CABG wall motion improvement ($p < 0.001$).

Conclusion: Stress/rest reversibility (impaired CFR) during dual-isotope gated myocardial perfusion SPECT was the single most important predictor of wall motion improvement after CABG.

Index terms: Myocardium; Tissue viability; Ischemia; Coronary artery bypass grafting; Single-photon emission-computed tomography

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INTRODUCTION

Myocardial viability is an important issue in the field of cardiology, because revascularization in the ischemic viable area improves regional wall motion, left ventricular (LV) function, and ultimately, outcomes of patients (1). The dysfunctional myocardium which is not viable should be managed by medical treatment, whereas the ischemic viable myocardium should be re-vascularized by coronary artery bypass graft (CABG) surgery or percutaneous coronary intervention. Therefore, it is important to predict the presence of viable myocardium in the management of patients with coronary artery disease (CAD) patients and particular in those with LV dysfunction (2).

In the field of nuclear cardiology are several tools available to detect viable myocardium. First, ^{201}Tl scintigraphy has been the most widely-investigated nuclear imaging tool (3, 4). Preserved ^{201}Tl uptake could indicate viable myocardium (4), because the degree of ^{201}Tl uptake is well correlated with the functioning mass of viable myocytes (5). The presence of early (1–6 hours post-injection) (3) or delayed (8–24 hours post-injection) (4) redistribution of ^{201}Tl has been the hallmark of viable myocardium. Furthermore, the low detectability of the ^{201}Tl redistribution protocol for viable myocardium could be improved through an additional investigation of ^{201}Tl re-injection (6, 7). Second, $^{99\text{m}}\text{Tc}$ -labeled agents such as $^{99\text{m}}\text{Tc}$ -methoxyisobutylisonitrile ($^{99\text{m}}\text{Tc}$ -MIBI) are promising radiopharmaceuticals for not only myocardial perfusion assessment but also myocardial viability assessment (8). Because of its excellent physicochemical properties, $^{99\text{m}}\text{Tc}$ -MIBI has been used for electrocardiographic (ECG)-gated myocardial single-photon emission computed tomography (SPECT) in which myocardial wall motion and wall thickening could be evaluated in addition to myocardial perfusion (9, 10). Last, a mismatch of perfusion and metabolism in positron emission tomography (PET) studies is another important finding characteristic for viable myocardium (11), although it is beyond the scope of the current study.

Among a number of myocardial SPECT protocols, the dual-isotope myocardial SPECT (rest ^{201}Tl /stress $^{99\text{m}}\text{Tc}$ -MIBI) protocol has been successfully applied to a variety of CAD conditions. The efficacy of the protocol for the detection of CAD has been validated in exercise (9) and pharmacologic stress (12). Transient LV dilatation measured on dual-isotope SPECT was a marker of severe and extensive CAD (13). The

prognosis of CAD could be effectively predicted using dual-isotope myocardial SPECT (14). However, the usefulness of the protocol in terms of detection of myocardial viability has not been thoroughly evaluated yet. Furthermore, if ECG-gating and ^{201}Tl 24 hours delayed redistribution studies were added to the dual-isotope protocol, valuable markers of viable myocardium such as stress/rest reversibility (in other words, coronary flow reserve [CFR] impairment), ^{201}Tl rest perfusion status, ^{201}Tl 24 hours redistribution and $^{99\text{m}}\text{Tc}$ -MIBI systolic wall thickening could be evaluated as a whole, and the gated LV ejection fraction (LVEF) would be easily assessed without additional procedures. More important, the competency of individual viability markers could be directly compared with each other, unveiling the most robust marker for myocardial viability. Thus, in the current study, we performed dual-isotope gated myocardial perfusion SPECT (rest ^{201}Tl /gated dipyridamole stress $^{99\text{m}}\text{Tc}$ -MIBI/24 hours redistribution of ^{201}Tl) in CAD patients before and 3 months after CABG surgery. The study purpose was to investigate the predictability of viable myocardium using dual-isotope gated myocardial SPECT and find the most competent marker of viable myocardium using multiple logistic regression analysis.

MATERIALS AND METHODS

Patients

The institutional ethical committee approved this study and an informed consent was obtained from the patients before the study. At our institute, CAD patients who are scheduled to have CABG surgery routinely undergo dual-isotope gated myocardial SPECT both pre-operative and 3 months post-operative. A total of 39 consecutive patients who had completed the pre-operative and post-operative SPECT studies over an 18-month period were enrolled in the current study (Table 1). The patients underwent CABG surgery because of multi-vessel CAD, left main disease or intractable chest pain. Patients with emergent CABG or without preoperative SPECT were excluded. The mean age was 58.0 ± 8.0 (mean \pm standard) years (range 36–72 years) and the male:female ratio was 34:5. Eleven patients got myocardial infarction at least 6 months prior to the current study.

Coronary angiography was conducted using the standard Judkins technique 1 month prior to CABG (1.0 ± 2.0 months before CABG). More than 70% stenosis was considered to be significant CAD with the consensus of 2 cardiologists. There were 24 three-vessel, 7 two-vessel and 4 one-vessel

diseases, as well as 4 cases of left main disease (Table 1).

Dual-Isotope Gated Myocardial SPECT

Gamma cameras equipped with high-resolution, parallel-hole collimators (Prism 3000, Picker or Vertex, ADAC, Houston, USA) were used for the SPECT studies. The consume of caffeine-rich food and the intake of nitrates or calcium-channel blockers was forbidden for at least 24 hours before the study and the patients came in a fasted state to the Department of Nuclear Medicine. SPECT in rest was first obtained for 10 minutes after the injection of ^{201}Tl . The dose of ^{201}Tl was adjusted according to the body weight, i.e., 74 MBq for less than 40 kg, 111 MBq for 40–70 kg, and 129.5 MBq for more than 70 kg. After the rest image acquisition, dipyridamole (0.56 mg/kg) was infused over

Table 1. Characteristics of Patients Who Participated in Study (n = 39)

Age, mean \pm SD (years)	58.0 \pm 8.0 (range, 36–72)
Male:Female	34:5
Previous myocardial infarction	n = 11
Coronary angiography	
Three-vessel disease	n = 24
Two-vessel disease	n = 7
One-vessel disease	n = 4
Left main coronary disease	n = 4*
CABG	
Arterial graft	49 units
Venous graft	60 units
Coronary angioplasty	Left main = 2, LAD = 3, RCA = 3
Other	Mitral valvuloplasty = 1

Note.— *Among 4 patients with left main coronary artery disease, 1 had left main disease alone, 2 had left main disease plus 1 vessel disease (LAD or RCA), and 1 had left main disease plus 2 vessel diseases (LAD and RCA). CABG = coronary artery bypass graft, LAD = left anterior descending artery, RCA = right coronary artery, SD = standard deviation

4 minutes and then $^{99\text{m}}\text{Tc}$ -MIBI (925 MBq) was injected 3 minutes after the completion of the dipyridamole infusion. Thirty minutes later, a fatty meal (1 whole egg and 180 mL of milk) was ingested to eliminate the gall bladder activity of $^{99\text{m}}\text{Tc}$ -MIBI. The gated stress SPECT was performed 1 hour after $^{99\text{m}}\text{Tc}$ -MIBI injection. ECG-gating was performed using frame mode (8 frames per cardiac cycle) acquisition. Sixteen patients showed perfusion defects in the ^{201}Tl rest images and underwent 24 hours delayed ^{201}Tl redistribution SPECT (Fig. 1).

Sixty projection images were acquired in 3° angular increments with the following parameters: a 30% energy window of 70 KeV for ^{201}Tl and a 20% energy window of 140 KeV for $^{99\text{m}}\text{Tc}$ -MIBI; acquisition from right anterior oblique 45° to left posterior oblique 45°; 15 s/stop for the Prism 3000 and 25 s/stop for the Vertex camera. The raw data were reconstructed using a Butterworth filter (cut-off frequency 0.35 cycles/pixel and order 10 for ^{201}Tl ; cut-off frequency 0.45 cycles/pixel and order 10 for $^{99\text{m}}\text{Tc}$ -MIBI) and reoriented into short, vertical long, and horizontal long axis images. The perfusion images were reconstructed from ungated projections of summed gated images.

Image Interpretation and Data Analysis

Two nuclear medicine physicians with expertise in nuclear cardiology interpreted in consensus the regional myocardial perfusion and wall motion. They were blinded to the clinical data at the time of interpretation. A standard 17 myocardial segment model was employed in the study. Perfusion status was graded semi-quantitatively using a 4-point system (normal = 0, mild decrease = 1, moderate decrease = 2, and severe defect = 3). Wall motion was also graded using a 4-point system (normal = 0, hypokinesia = 1, akinesia = 2, and dyskinesia = 3).

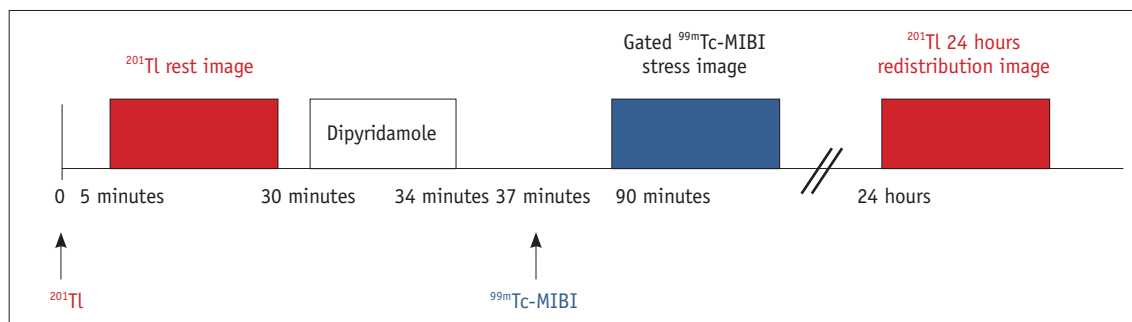


Fig. 1. Dual-isotope gated myocardial single-photon emission computed tomography protocol. ^{201}Tl was first injected and rest image was acquired. Pharmacologic stress using dipyridamole (0.56 mg/kg over 4 minutes) was performed. $^{99\text{m}}\text{Tc}$ -MIBI was injected 3 minutes after completion of dipyridamole infusion. Electrocardiography-gated stress image was obtained 1 hour later. ^{201}Tl 24 hours redistribution study was performed in case of rest perfusion defects. $^{99\text{m}}\text{Tc}$ -MIBI = $^{99\text{m}}\text{Tc}$ -methoxyisobutylisonitrile

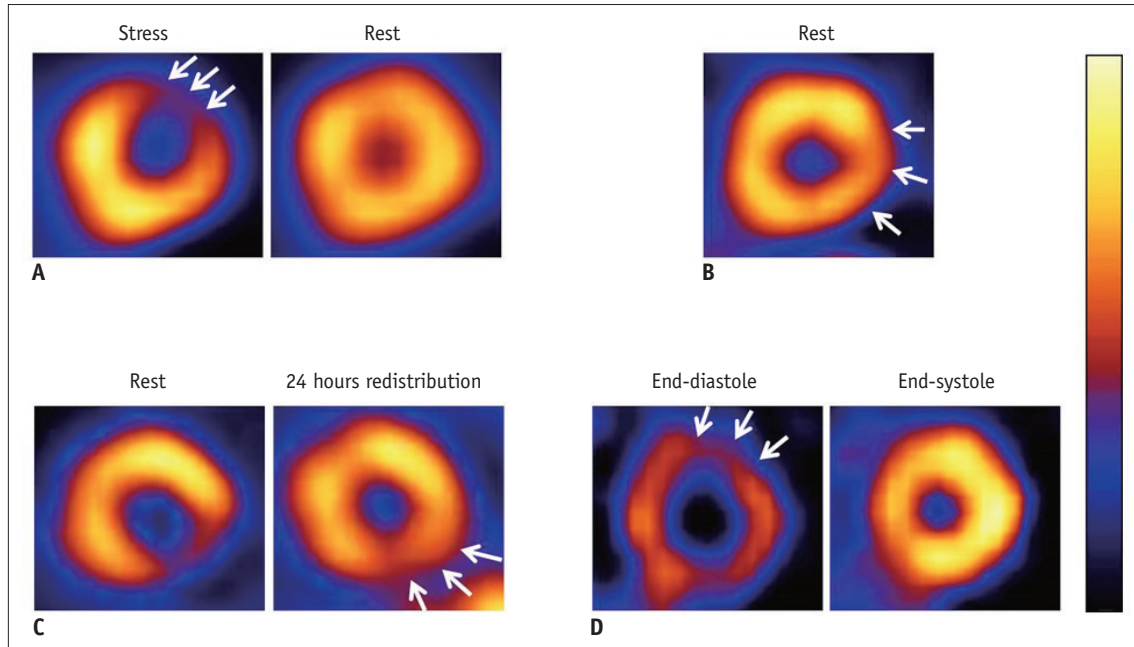


Fig. 2. Viable myocardium according to viability markers of dual-isotope gated myocardial single-photon emission computed tomography.

A. Stress/rest reversibility. **B.** ^{201}Tl rest perfusion status. **C.** ^{201}Tl 24 hours redistribution. **D.** $^{99\text{m}}\text{Tc}$ -methoxyisobutylisonitrile systolic wall thickening. All myocardial segments indicated by white arrows presented wall motion abnormality before revascularization and improved wall motion after revascularization. Arrows indicate the myocardial segments of interest regarding the myocardial viability.

The presence of stress/rest reversibility was defined as at least one grade improvement of rest perfusion when compared to the stress perfusion decrease or defect (Fig. 2A). Regarding ^{201}Tl rest perfusion status, normal-to-moderate perfusion decreases (grades 0–2) were considered to indicate viable myocardium (Fig. 2B). The presence of ^{201}Tl 24 hours delayed redistribution was defined as at least 1 grade improvement of ^{201}Tl uptake compared to ^{201}Tl rest perfusion defect (grade 3) (Fig. 2C). Gated systolic wall thickening was dichotomized into good or poor with regard to signal increase on systolic contraction (Fig. 2D).

The viable myocardium in the current study was defined as the dysfunctional myocardium which showed at least 1 grade improvement of myocardial wall motion after CABG using the 4-point grading system. The predictability of viable myocardium from the perspective of individual viability markers and composites of all the viability markers were analyzed. The most robust viability marker was investigated using univariate and multiple logistic regression analyses.

Statistical Analysis

Continuous variables like LVEF were compared using a paired *t* test. Variables with *p* value less than 0.25 in the univariate logistic regression analysis were chosen for the

subsequent forward and backward stepwise multiple logistic regression analysis. Commercial software (MedCalc, version 12.4.0.0, Ostend, Belgium) was used for statistical analyses. A *p* value of < 0.05 was considered statistically significant.

RESULTS

LVEF Change

The gated LVEFs of 34 patients could be evaluated before and after CABG. They ranged from 12% to 66% (mean \pm standard = $45.8 \pm 13.3\%$) before CABG and 15% to 65% ($48.4 \pm 12.0\%$) after CABG. There was no significant change in LVEF (*p* = 0.097, paired *t* test). However, when the pre-CABG LVEFs were limited to below 50% (*n* = 22), the post-CABG LVEFs improved significantly from $37.8 \pm 9.0\%$ to $45.5 \pm 12.3\%$ (*p* < 0.001) (Fig. 3).

Regional Wall Motion Improvement

Of the 590 re-vascularized myocardial segments, 142 segments showed preoperative wall motion abnormality. Twenty-seven myocardial segments with normal perfusion at stress and rest were excluded and the remaining 115 myocardial segments were analyzed. After CABG, 85 segments (73.9%; 85 of 115) experienced wall motion improvement and these segments were considered as viable

Stress-Rest Reversibility as a Marker of Viable Myocardium

myocardium.

Viability Prediction of Markers

Stress/Rest Reversibility

Among the 115 dysfunctional myocardial segments, 85 turned out to be viable and 30 to be non-viable. The sensitivity, specificity, positive predictive value (PPV), negative predictive value (NPV), and accuracy were 80.0% (68 of 85), 53.3% (16 of 30), 82.9% (68 of 82), 48.5% (16 of 33), and 73.0% (84 of 115), respectively (Table 2, Fig. 4).

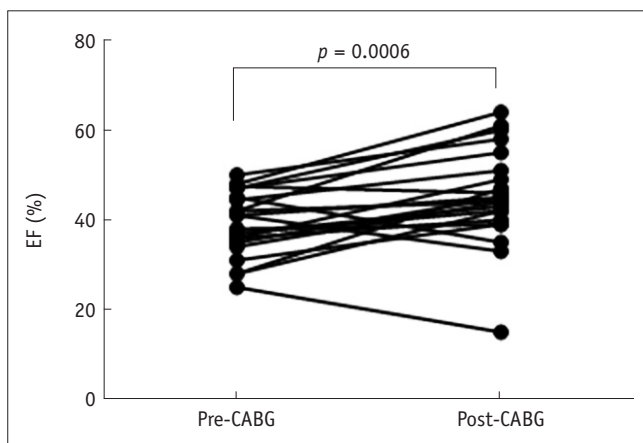


Fig. 3. LVEF change after CABG. Gated LVEF increased significantly ($p < 0.001$) after CABG ($45.5 \pm 12.3\%$) in 22 patients with pre-CABG LVEFs lower than 50% ($37.8 \pm 9.0\%$). CABG = coronary artery bypass graft, LVEF = left ventricular ejection fraction

²⁰¹Tl Rest Perfusion Status

Of the 115 dysfunctional segments, 90 showed preserved perfusion and 25 showed perfusion defects. The sensitivity, specificity, PPV, NPV, and accuracy were 83.5% (71 of 85), 36.7% (11 of 30), 78.9% (71 of 90), 44.0% (11 of 25), and 71.3% (82 of 115), respectively (Table 2, Fig. 4).

²⁰¹Tl 24 Hours Redistribution

Of the 25 myocardial segments on which ²⁰¹Tl rest perfusion status was defined as severe defect (grade 3), only 18 segments underwent ²⁰¹Tl 24 hours redistribution study and of them were 8 viable and 10 non-viable; 6 redistribution-positive and 12 redistribution-negative. The sensitivity, specificity, PPV, NPV, and accuracy were 37.5% (3 of 8), 70.0% (7 of 10), 50.0% (3 of 6), 58.3% (7 of 12), and 55.6% (10 of 18), respectively (Table 2, Fig. 4).

^{99m}Tc-MIBI Systolic Wall Thickening

Of the dysfunctional 115 segments, 72 showed a good and 43 a poor myocardial wall thickening. The sensitivity, specificity, PPV, NPV, and accuracy were 60.0% (51 of 85), 30.0% (9 of 30), 70.8% (51 of 72), 20.9% (9 of 43), and 52.2% (60 of 115), respectively (Table 2, Fig. 4).

Viability Prediction as a Whole

²⁰¹Tl 24 hours redistribution was excepted because of the small number of its contributing segments. Therefore 115 myocardial segments could be evaluated using 3 viability

Table 2. Prediction of Viable Myocardium Using Individual Viability Markers

		Viable	Non-Viable
Dysfunctional segments before CABG	142		
After exclusion of dysfunctional segments with normal perfusion at stress and rest (n = 27)	115	85	30
Viability markers			
Stress/rest reversibility	115	Positive	68
		Negative	17
		Total	85
²⁰¹ Tl rest perfusion	115	Positive	71
		Negative	14
		Total	85
²⁰¹ Tl 24 hours redistribution	18*	Positive	3
		Negative	5
		Total	8
^{99m} Tc-MIBI systolic wall thickening	115	Positive	51
		Negative	34
		Total	85

Note.— *²⁰¹Tl 24 hours redistribution was evaluated in only 18 myocardial segments that had rest perfusion defect. CABG = coronary artery bypass graft, ^{99m}Tc-MIBI = ^{99m}Tc-methoxyisobutylisonitrile

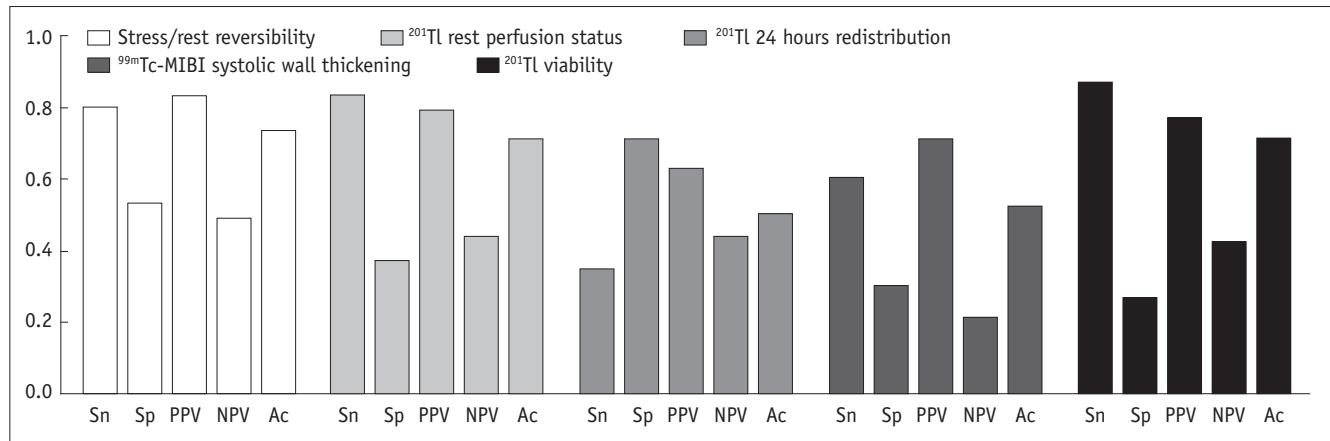


Fig. 4. Diagnostic performances of individual viability markers for wall motion improvement. Ac = accuracy, NPV = negative predictive value, PPV = positive predictive value, Sn = sensitivity, Sp = specificity, ^{99m}Tc-MIBI = ^{99m}Tc-methoxyisobutylisonitrile

Table 3. Results of Logistic Regression Analysis

Variable	Univariate Logistic Regression Analysis		Multiple Logistic Regression Analysis	
	Odds Ratio	P	Adjusted Odds Ratio	P
Stress/rest reversibility	4.5714	< 0.001	4.5714	< 0.001
²⁰¹ Tl rest perfusion	2.9361	0.024	Not included*	
²⁰¹ Tl 24 hours redistribution	1.3158	0.659		
^{99m} Tc-MIBI systolic wall thickening	0.6429	0.332		
²⁰¹ Tl viability	2.4463	0.088	Not included*	

Note.— *Those 2 variables were included in multiple regression analysis at first but excluded during stepwise modeling. ^{99m}Tc-MIBI = ^{99m}Tc-methoxyisobutylisonitrile

markers (stress/rest reversibility, ²⁰¹Tl rest perfusion status, and ^{99m}Tc-MIBI systolic wall thickening). When any 1 of 3 viability markers indicated myocardial viability, viability was considered positive and when all markers indicated non-viability, viability was considered negative. The sensitivity, specificity, PPV, NPV, and accuracy were 90.6% (77 of 85), 20.0% (6 of 30), 76.2% (77 of 101), 42.9% (6 of 14), and 72.2% (83 of 115), respectively.

²⁰¹Tl Viability

²⁰¹Tl viability was defined with either normal-to-moderate degree rest perfusion decrease (grade 0–2) or severe perfusion defect (grade 3) accompanied by delayed redistribution. Of the 115 dysfunctional segments, 96 were positive and 19 negative for ²⁰¹Tl viability. The sensitivity, specificity, PPV, NPV, and accuracy were 87.1% (74 of 85), 26.7% (8 of 30), 77.1% (74 of 96), 42.1% (8 of 19), and 71.3% (82 of 115), respectively.

Logistic Regression Analysis

Using univariate analysis, stress/rest reversibility ($p < 0.001$) and ²⁰¹Tl rest perfusion status ($p = 0.024$) showed significant predictability, whereas ²⁰¹Tl 24 hours

redistribution ($p = 0.738$), ^{99m}Tc-MIBI systolic wall thickening ($p = 0.332$), and ²⁰¹Tl viability ($p = 0.088$) were no significant predictors of wall motion improvement. However, in multiple logistic regression analysis, only stress/rest reversibility continued to show significant predictability for wall motion improvement ($p < 0.001$) (Table 3).

Subgroup Analysis

We evaluated the predictability of wall motion improvement in 2 subgroups. First, 39 myocardial segments with normal ²⁰¹Tl rest perfusion were excluded because those segments may indicate stunned myocardium that would have improved wall motion even without revascularization. After exclusion of those 39 segments, the multiple logistic regression analysis in the remaining 76 segments revealed that only stress/rest reversibility was an important predictor of wall motion improvement (odds ratio = 4.0909, $p = 0.022$). Second, on the 22 patients with a pre-CABG LVEF lower than 50% (mean \pm standard = 37.8 \pm 9.0%), the stress/rest reversibility was again the most predictable marker of wall motion improvement (odds ratio = 3.8503, $p = 0.005$).

DISCUSSION

It is well known that reversible perfusion defects have ischemic viable myocardium in ^{201}Tl scintigraphy (15). Myocardium with reversible perfusion defects has been considered viable. It has not been considered because there was stress-induced ischemia, but because there was some degree of reuptake or redistribution of ^{201}Tl . With regard to the detection of viable myocardium, the reversibility from the stress defect was considered to be equivalent to the reversibility from the rest defect. Therefore stress image acquisition was not always required for a viability assessment; the ^{201}Tl rest-redistribution study was considered sufficient for detection of viable myocardium (16, 17).

It is noteworthy that the recent paradigm shift regarding the concept of hibernating myocardium puts tremendous emphasis on impaired CFR as an early manifestation of dysfunctional myocardium (18, 19). The chronic stunned state, preceding the hibernating state, presents features of abnormal wall motion and impaired CFR, while the rest perfusion is preserved (18). Myocardial hibernation occurs as a result of adaption to impaired CFR and repetitive stunning, rather than to a myocardial hypoperfusion (18). Moreover, the progression from chronic stunning to hibernation comes up with myocardial apoptosis (20), suggesting the dysfunctional myocardium in the chronic stunned state is more likely to improve wall motion after revascularization than that in a hibernating state under the influence of apoptosis. Therefore, if a certain viability marker is more inclined to detect chronic stunned myocardium, the marker may appear more competent than any other marker for viability detection.

In the current study, stress/reversibility (Fig. 2A) was the single most important predictor of viable myocardium with the greatest accuracy, whereas ^{201}Tl rest perfusion status (Fig. 2B), ^{201}Tl 24 hours redistribution (Fig. 2C), and $^{99\text{m}}\text{Tc}$ -MIBI systolic wall thickening (Fig. 2D) did not show significant predictability in the multiple logistic regression analyses. Results of the current study can be explained in several ways. First, stress perfusion has its own utility for the viability assessment by evaluating CFR and impaired CFR may indeed reflect the necessity of revascularization of ischemic viable myocardium. Not only in chronic stunned myocardium, but also in hibernating myocardium, the impaired CFR must be playing an important role in viability detection where the stress/rest reversibility (impaired CFR) proved to be the most robust detector of viable myocardium

in the subgroup analysis, excluding stunned myocardium. Of course, a rest study is essential in order to evaluate the CFR (here, relative CFR using myocardial SPECT rather than absolute CFR using myocardial PET), but it was not the preserved rest perfusion but the impaired CFR that required revascularization surgery for wall-motion improvement. Second, from a practical point of view to identify ischemic dysfunctional myocardium, detecting the deterioration of myocardial function may be a better method than detecting the improvement of myocardial function. For example, the residual viable myocytes in the infarct zone, hardly identified by other routine tests, have been found to trigger ventricular arrhythmia with exercise-induced ischemia. It means that functional deterioration (in this case aberrant electrical conductance) could indicate the presence of viable myocytes in the infarct zone (21). During dobutamine echocardiography, a continuous worsening of wall-motion response was a better predictor of viable myocardium than a sustained improvement response. It means that functional deterioration (wall motion abnormality) is more likely to indicate viable myocardium than wall motion improvement during dobutamine administration (22). Improvement of myocardial function during stress may take place in either normal myocardium or ischemic viable myocardium or in a mixture of both. But a deterioration of myocardial function on the usual diagnostic tests may only occur in the ischemic viable myocardium. Taken this findings together the authors believe that the deterioration of regional myocardial perfusion during stress may indicate the presence of ischemic viable myocardium. Third, individual viability markers may represent different phases during the progression of myocardial dysfunction and accordingly the time to full recovery after revascularization may differ. Dobutamine stress echocardiography has been reported to detect recovering dysfunctional myocardium just a few weeks after CABG (16). The dysfunctional myocardium with stress/rest reversibility mainly presented wall-motion improvement 3 months post-CABG (23). It took more than 6 months or up to 1 year post-revascularization for the ^{201}Tl uptake-positive dysfunctional myocardium to recover (16). In this regard, ^{201}Tl uptake might have been a more significant marker of viable myocardium if we had evaluated post-CABG wall motion at periods later than 3 months post-CABG. Further studies are needed to investigate the issue of a delayed functional restoration of the viable myocardium.

As for $^{99\text{m}}\text{Tc}$ -MIBI systolic wall thickening, the low sensitivity (66%) and NPV (20.5%) were not inconsistent

with a previous study (8). As a matter of fact, in contrast of large amounts of data regarding systolic wall thickening on echocardiography as a predictor of wall motion improvement after revascularization (24), ^{99m}Tc -MIBI systolic wall thickening has not been fully evaluated so far yet (8). Furthermore, the value of ^{201}Tl systolic wall thickening as a marker of viable myocardium has not been thoroughly evaluated (25). We think further studies are required for gated myocardial parameters to be used as viability markers.

The results of recent randomized clinical trials regarding the efficacy of revascularization over viable myocardium triggered a debate regarding the utility of viability tests (17, 26). A number of viability studies have been reported with variable degrees of success. However, the critical question regarding the most robust marker of viable myocardium was not an issue until the efficacy of revascularization was challenged by randomized clinical trials (19). In this regard, the results of the current study may lead not only nuclear medicine physicians to a glimpse of the viable myocardium, but also the results may lead back to the basic question: what is viable myocardium (2)?

Limitation

The most critical weak point of the current study is the use of post-stress wall motion for the evaluation of the wall motion change. Myocardial stunning may have happened in some myocardial segments during the post-stress gate image acquisition. Those myocardial segments have potential of wall motion improvement even without revascularization. However, ^{201}Tl rest SPECT seems not to be the better option than ^{99m}Tc -MIBI post-stress SPECT for the evaluation of myocardial wall motion. This issue needs further investigation. Another weak point of the present study is the fact that only wall motion improvement was assessed as a short-term outcome. Viability studies usually require a long-term outcome as final end-point (27). Furthermore, how much viable myocardium was required for long-term improvement was another critical question which could not be answered appropriately (28). Lastly, the effects of intense cardioprotective medication were not evaluated in the current study (17).

Conclusion

The stress/rest reversibility (in other words, impaired CFR) during dual-isotope gated myocardial perfusion SPECT was the most important marker for the prediction of wall motion improvement in 3 months post-CABG.

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