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〔Original Paper〕

Comparison of I-123 BMIPP, Tc-99m MIBI, and Tl-201 myocardial SPECT for prediction of late left ventricular function after reperfusion therapy for acute myocardial infarction

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SUMMARY

We prospectively evaluated I-123 beta-methyliodophenylpentadecanoic acid (BMIPP), Tc-99m methoxyisobutyl isonitrile (MIBI) and Tl-201 (Tl) SPECT images in 21 patients to determine which agent most accurately predicts late left ventricular function in patients with acute myocardial infarction (AMI). In all cases, the infarct-related artery was revascularized by primary PTCA. We performed SPECT with each of these three radionuclides at the subacute phase (1-3 weeks) of myocardial infarction. Polar map images were quantitatively compared to normal data from a data bank. Late left ventricular ejection fraction (EF) was calculated by contrast ventriculography at 4 months after the onset of myocardial infarction.

The mean defect sizes (>2 standard deviation below the mean count for normal data bank) by BMIPP, early Tl, delayed Tl and MIBI SPECT were 43%, 33%, 35% and 36%, respectively. There were good correlations between late EF and defect size by BMIPP (r=0.77, p=0.0003), early Tl (r=0.69, p=0.002), delayed Tl (r=0.65, p=0.005) and MIBI (r=0.67, p=0.004).

In conclusion, BMIPP imaging at the subacute phase of AMI is superior to rest Tl and MIBI imaging for prediction of late left ventricular function in AMI patients with successful reperfusion therapy.

Key words : I-123 BMIPP, Tc-99m MIBI, Tl-201, acute myocardial infarction

Abbreviations : BMIPP : beta-methyliodophenylpentadecanoic acid
MIBI : methoxyisobutyl isonitrile
SPECT : single photon emission computed tomography
AMI : acute myocardial infarction
EF : ejection fraction
IRA : infarct-related artery

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I. Introduction

Left ventricular function after myocardial infarction is the strongest predictor of patient outcome[1]. Multiple randomized control trials have used left ventricular ejection fraction as a surrogate end-point of outcome in patients treated with thrombolytic therapy during acute myocardial infarction. However, several reports have demonstrated delayed improvement of left ventricular ejection fraction in patients receiving acute reperfusion therapy for myocardial infarction[2-6], and suggested that left ventricular ejection fraction before hospital discharge does not accurately reflect infarct size and is different from that in the chronic stable period because of the presence of stunned myocardium and compensating hyperkinetic movement of noninfarct area[2-9]. Several studies have therefore delayed the assessment of left ventricular function until the postdischarge period[10-12]. Thus, prediction of the truly recovered left ventricular function is important for risk stratification in patients with acute myocardial infarction.

Several studies for predicting late left ventricular function of acute myocardial infarction by the use of certain nuclear agents have been reported. The extent of Tc-99m MIBI defect at the subacute phase of myocardial infarction more closely correlates with the late left ventricular function rather than ventricular function at the subacute phase[9]. The defect size of BMIPP, a myocardial fatty acid imaging agent, more closely correlates with ejection fraction at the time of chronic phase than the defect size of Tl[13]. However, there has been no report concerning a comparison of I-123 BMIPP, Tc-99m MIBI and Tl-201 myocardial SPECT images. Therefore, to determine which agent most accurately predicts the late left ventricular function in patients with acute myocardial infarction, we prospectively evaluated these three myocardial SPECT images at the subacute phase of myocardial infarction.

II. Materials and Methods

Patients

Twenty-one consecutive patients with first acute myocardial infarction admitted to Yokohama Rosai Hospital within 6 hours of the onset of symptoms were studied (Table 1). The patients were 17 men and 4 women with a mean age of $62\pm11(\pm s)$. The diagnosis of acute myocardial infarction was determined by the presence of persistent ST segment elevation of >2 mm in two or more leads on the electrocardiogram associated with precordial pain typical of acute myocardial infarction.

Selective coronary angiography was performed in all patients immediately after being admitted. The infarct-related artery was the left anterior descending artery in 15 (71%) cases, the right coronary artery in 4 cases (19%), and the circumflex artery in 2 cases (10%). All patients underwent emergent angioplasty and then all infarct-related arteries were confirmed by TIMI 3 flow.

Table 1. Clinical parameters of the study patients

Age (yr)	62±11
Sex (male)	17 (81%)
IRA	
LAD	15 (71%)
RCA	4 (19%)
LCX	2 (10%)

IRA, infarct-related artery; LAD, left anterior descending; RCA, right; LCX, left circumflex.

Radionuclide studies

Rest I-123 BMIPP, Tl-201, and Tc-99m MIBI

SPECT images were separately taken in randomized order at the subacute phase of myocardial infarction. I-123 BMIPP SPECT images were obtained 20 min after injection of 111 MBq of the agent. Tl-201 SPECT images were obtained 5 min (early image) and 4 hr (delayed image) after injection of 111 MBq of the radionuclide. Tc-99m MIBI SPECT images were obtained 1 hr after injection of 600 MBq of the agent.

All images were obtained on a triple-head rotating gamma camera equipped with a low energy, high resolution collimator (Toshiba GCA- 9300A). Sixty frames were obtained at 60 sec/view interval over a 360 arc. Energy discrimination was provided by a 20% window centered on 80 keV for Tl-201, 159 keV for I -123 BMIPP and 140 keV for Tc-99m MIBI. A series of transaxial images of 6 mm thickness were reconstructed by back projection technique without attenuation correction. Polar map images were generated for 20 radii by identifying the peak counts in every 10° sector around the left ventricle. Polar map images were quantitatively compared to normal data of a data bank separately generated for each test. The area showing $>2s$ below the mean count of the normal data was defined as hypoperfused area, and the percentage of hypoperfused left ventricule was calculated as % defect.

Follow-up study

Follow-up coronary angiography and contrast left ventriculography (RAO 30°) were performed at 3 weeks after onset ($n=17$) and 4 months after onset ($n=16$). At 4 months, coronary angiography showed restenosis of infarct-related artery in 5 patients (32%), and reocclusion in none. Ejection fraction was calculated by the area length method.

Statistical analysis

Data are presented as mean values ± *s*. Simple linear regression analysis was used to compare % defect by I-123 BMIPP, Tl-201 and Tc-99m MIBI images with ejection fraction. A paired *t* test was used to compare ejection fraction at 3 weeks and 4 months after onset. One-way factorial ANOVA and multiple comparison test were used to compare % defect by I-123 BMIPP, early Tl-201, delayed Tl-201 and Tc-99m MIBI images.

Ⅲ. Results

Left ventricular function

Left ventriculography was performed in 17 patients at 3 weeks of the disease after onset (mean 23±7 days), and 16 patients at 4 months of the disease after onset (mean 117 ±16 days). Ejection fraction (EF) at 3 weeks after onset was 52±14%, and that at 4 months was 58±13%. Fifteen of the patients underwent left ventriculography two times. In these 15 patients, there was a significant increase in EF from 3 weeks after onset to 4 months (Fig. 1).

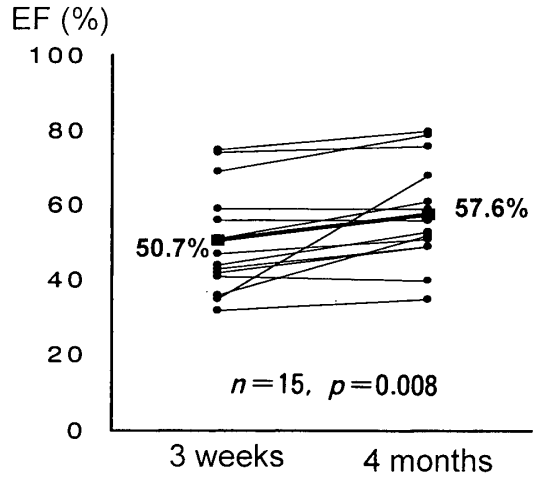

Fig. 1 Ejection fraction (EF) at 3 weeks after onset and that at 4 months. Fifteen of the patients underwent left ventriculography two times. In these 15 patients, there was a significant increase in EF from 3 weeks after onset to 4 months.

Radionuclide parameters

Rest I-123 BMIPP, rest Tl-201, and rest Tc-99m MIBI SPECT were performed at 14±4 days, 12±4 days, and 20±8 days after onset, respectively. The % defect by I-123 BMIPP was 43±17%, that by early Tl-201 33±21%, that by delayed Tl-201 35±13%, and that by Tc-99m MIBI 36±17%. The % defect by I-123 BMIPP was larger than those by the other agents, but there was no statistical significance between any of the differences (Fig. 2).

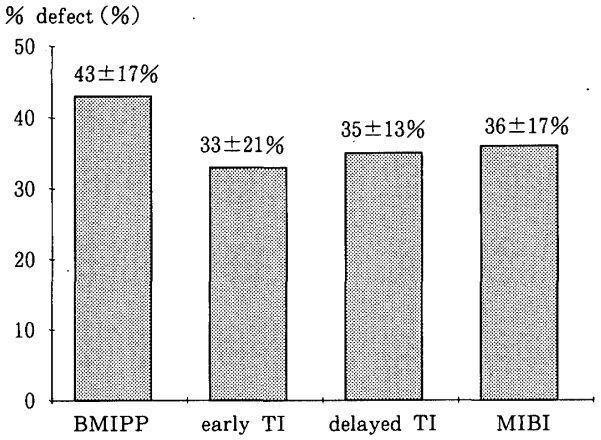

Fig. 2 Rest I-123 BMIPP, rest Tl-201, and rest Tc-99m MIBI SPECT were performed at 14±4 days, 12±4 days, and 20±8 days after onset. The % defect by I-123 BMIPP was larger than those by the other agents, but there was no statistical significance between any of the differences .

Correlation of radionuclide studies

Correlation coefficients between % defect by the respective radionuclide studies and EF at 3 weeks and 4 months after onset are shown in Table 2. The % defect by each radionuclide was more closely correlated with

Table 2.

	3weeks	4months
BMIPP	−0.59 (p=0.01)	−0.77 (p=0.0003)
early TI	−0.38 (p=0.13)	−0.69 (p=0.002)
delayed TI	−0.47 (p=0.06)	−0.65 (p=0.005)
MIBI	−0.46 (p=0.06)	−0.67 (p=0.004)

Correlation coefficients between % defect by the respective radionuclide studies and EF at 3 weeks and 4 months after onset. The % defect by each radionuclide was more closely correlated with EF at 4 months than at 3 weeks after onset. The best correlation coefficient was found between % defect by I-123 BMIPP and EF at 4 months after onset (r=−0.77).

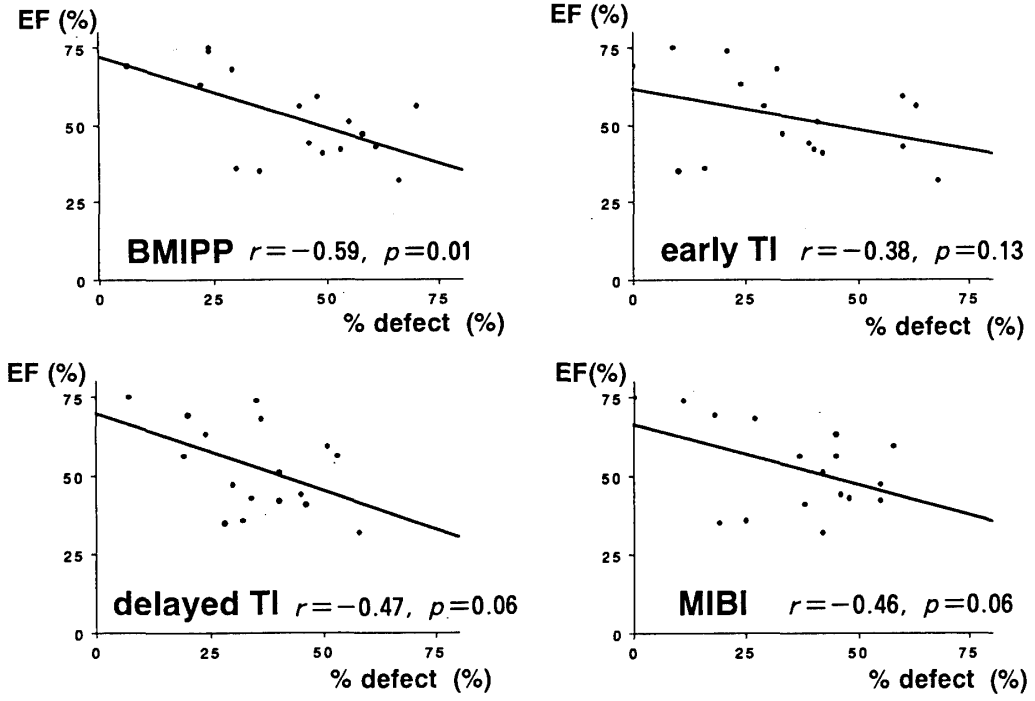

Fig. 3 Comparison of % defect by each radionuclide studies and ejection fraction at 3 weeks after onset.

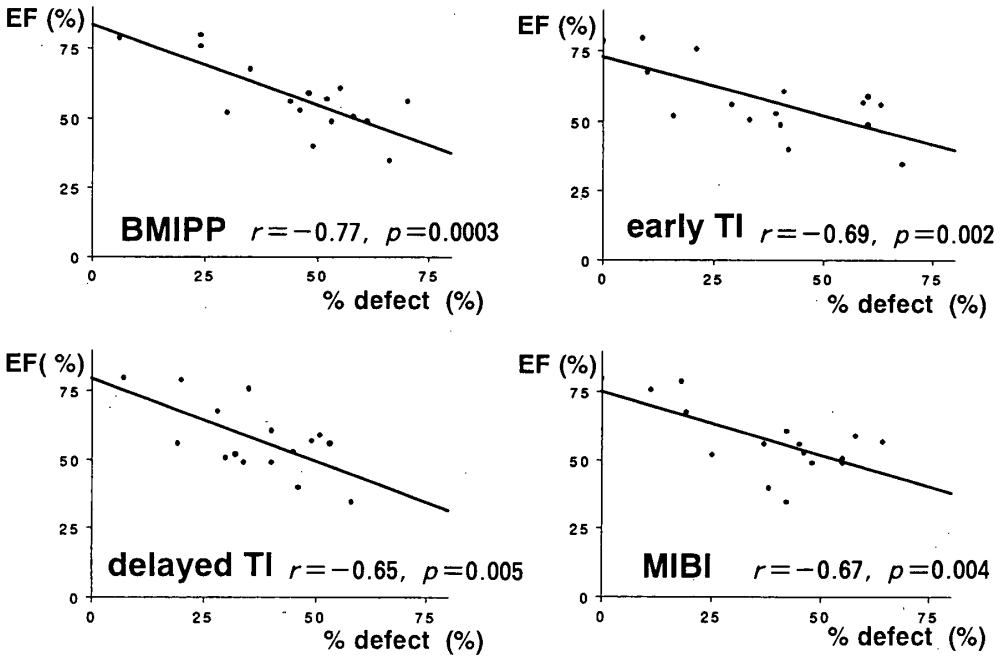

Fig. 4 Comparison of % defect by each radionuclide studies and ejection fraction at 4 months after onset. The best correlation coefficient was found between % defect by I-123 BMIPP and EF at 4 months after onset ($r=-0.77$).

EF at 4 months than at 3 weeks after onset. The best correlation coefficient was found between % defect by I-123 BMIPP and EF at 4 months after onset ($r=-0.77$) (Fig. 3, 4).

IV. Discussion

The accurate prediction of left ventricular function recovery is clinically important. The % defect by I-123 BMIPP, Tl-201 and Tc-99m MIBI studies at the subacute phase of myocardial infarction was more closely correlated with EF at the chronic phase than at the subacute phase, although 5 patients (24%) had a significant increase ($\geqq$8%) in EF at 4 months compared with that at 3 weeks. Christian et al have already reported that the defect size of Tc-99m MIBI in acute myocardial infarction patients at the time of discharge more accurately reflects EF at the chronic phase rather than that at discharge[9]. This finding suggests that the defect size of these radionuclide studies may not be affected by the presence of stunned myocardium and hyperkinesia of noninfarct area even if the study is performed at the subacute phase of myocardial infarction. This is an advantage of the nuclear method compared to the echocardiographic assessment at rest.

The metabolic approach may be theoretically superior to the flow approach because metabolic activity in the myocardium is more directly associated with wall motion (metabolic-contraction coupling). I-123 BMIPP was developed for fatty acid metabolic imaging with SPECT. In animal studies, myocardial uptake of I-123 BMIPP has been shown to reflect the myocardial intracellular ATP concentration, triglyceride content, and mitochondrial function[14-17]. In clinical studies, I-123 BMIPP findings were more closely correlated with ventricular function in the acute phase of myocardial infarction than Tl-201 findings[18,19], and the extent of I-123 BMIPP defect at the subacute phase in myocardial infarction patients was more strongly correlated with EF than that of Tl-201[13].

By defining hypoperfusion as $<2s$ compared with the normal data of a data bank, we measured the extent of hypoperfusion but not its severity. The influence of the severity of the perfusion defect needs to be assessed. However, in animal studies[20], the extent of hypoperfusion has been shown to accurately distinguish infarcted from noninfarcted myocardium.

This is the first report to show the direct and quantitative comparison among I-123 BMIPP, Tl-201 and Tc-99m MIBI in acute myocardial infarction patients with successful reperfusion therapy, and to examine which agent can most accurately predict late left ventricular function. The value of the % defect by I-123 BMIPP was the largest among of them. Our results were similar to those of previous studies[18,19,21]. Further, the % defect by I-123 BMIPP was most strongly correlated with EF at the chronic phase compared with those by early Tl-201, delayed Tl-201 and Tc-99m MIBI. A possible explanation for this difference is that I-123 BMIPP is more sensitive to ischemia than the other agents. Additional experimental studies will be needed to clarify the exact mechanism of this phenomenon.

Conclusion

The % defect by all radionuclide studies at the subacute phase of myocardial infarction was more closely correlated with ejection fraction at the chronic phase than that at the subacute phase. I-123 BMIPP imaging at the subacute phase of myocardial infarction is superior to rest Tl-201 and Tc-99m MIBI imaging for prediction of late left ventricular function in acute myocardial infarction patients with successful reperfusion therapy.

要　旨

心筋梗塞患者における慢性期左心機能の評価は予後を検討する上で重要である。今回再潅流療法を施行した急性心筋梗塞患者において，亜急性期に施行したI-123 BMIPP, Tl-201, Tc-99m MIBI SPECT検査のうちどの核種が最も慢性期左心機能の予測に有用かを定量的に検討した。

急性心筋梗塞21例（平均62才）に対し亜急性期（平均15病日）に順不同にI-123 BMIPP, Tl-201, Tc-99m MIBI SPECT検査を施行し各polar mapを作製した。各polar mapをそれぞれのnormal data bankと比較し，$-2s$以下を示した領域をhypoperfused areaとして% defectを算出，心筋梗塞発症4カ月後の左室造影より得られた駆出率と比較した。

I-123 BMIPPの初期像，Tl-201の初期像,後期像，Tc-99m MIBIの初期像の% defectはそれぞれ43±17%，33±21%，35±13%，36±17%であった。心筋梗塞発症4カ月後の駆出率との相関は，I-123 BMIPP初期像が最も強く（相関係数$r=-0.77$, $p=0.0003$），次いでTl-201早期像（$r=-0.69$, $p=0.002$），Tl-201後期像（$r=-0.65$, $p=0.005$），Tc-99m MIBI早期像（$r=-0.67$, $p=0.004$）の順であった。

上記3種核種中，再潅流療法を施行した急性心筋梗塞症例において慢性期左心機能の予測にはI-123 BMIPP SPECT検査が最も有用であった。

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