Evaluation of Myocardial Perfusion and Fatty Acid Uptake Using a Single Injection of Iodine-123-BMIPP in Patients with Acute Coronary Syndromes

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The purpose of this study was to clarify the possibility of simultaneous evaluation of myocardial perfusion and fatty acid metabolism using a single injection of ^{123}I-beta-methyl-p-iodophenyl-pentadecanoic acid (BMIPP) in patients with acute coronary syndromes. **Methods:** Thirty patients with unstable angina pectoris (UAP group) and 15 patients with acute myocardial infarction (MI group) were studied. BMIPP dynamic SPECT was performed 2 min after the injection of BMIPP (185 MBq), and images were obtained every 3 min for 15 min with a three-head gamma camera. Conventional BMIPP SPECT was also performed 30 min after the injection. Serial BMIPP and resting ^{201}Tl images were compared. **Results:** A ^{201}Tl-BMIPP mismatch between 30-min BMIPP and resting ^{201}Tl images was observed in 27 of 30 patients in the UAP group and 8 of 15 patients in the MI group, respectively. However, a ^{201}Tl-BMIPP mismatch between early (2–5-min) BMIPP and resting ^{201}Tl images was observed in only 2 of 30 patients in the UAP group and in only 2 of 15 patients in the MI group, respectively. The kappa statistics of tracer uptake between early BMIPP and resting ^{201}Tl images showed good concordance in UAP ($\kappa = 0.823$) and MI ($\kappa = 0.765$) groups, respectively. These results indicated that initial distribution of BMIPP reflects myocardial perfusion in patients with acute coronary syndromes. **Conclusion:** Myocardial perfusion and fatty acid metabolism can be evaluated simultaneously using a single injection of BMIPP, when images are taken soon (2–5 min) and long after the injection in patients with acute coronary syndromes.

Key Words: iodine-123-beta-methyl-p-iodophenyl-pentadecanoic acid; fatty acid metabolism; myocardial perfusion; acute coronary syndromes; dynamic SPECT

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Iodine-123-beta-methyl-p-iodophenyl-pentadecanoic acid (BMIPP) is a branched chain fatty acid analog that is labeled with ^{123}I. BMIPP has been clinically applied as a means of reflecting myocardial fatty acid metabolism in patients with ischemic heart disease (*1–10*). Abnormal fatty acid metabolism was estimated as a mismatched tracer activity between BMIPP and ^{201}Tl or sestamibi images (*1–10*). In these cases, resting perfusion images are always required to analyze BMIPP images (*1–9*).

Matsunari et al. (*11*) reported early kinetics of BMIPP in patients with myocardial infarction and noted a transient accumulation (backdiffusion) of this radiopharmaceutical immediately after injection. The mechanism of BMIPP backdiffusion may occur when the conversion of BMIPP to BMIPP-coenzyme A is suppressed in the metabolically impaired myocardium, preventing free BMIPP from being retained in the myocardial cell (*11*). If an image immediately after the injection of BMIPP represents myocardial perfusion, it will be possible to evaluate both myocardial perfusion and fatty acid metabolism simultaneously using a single dose of BMIPP.

In this study, BMIPP SPECT images, taken soon and long after the injection, were compared with resting ^{201}Tl images to evaluate the possibility of simultaneous evaluation of myocardial perfusion and fatty acid metabolism using a single injection of BMIPP in patients with acute coronary syndromes.

MATERIALS AND METHODS

Patients

Forty-five patients with acute coronary syndromes who had been referred to our hospital were enrolled in this study [8 women, 37 men; age range 61.9 ± 9.2 yr (mean ± s.d.)]. The patients were divided into two groups: the UAP group (30 with unstable angina pectoris, including 5 with old myocardial infarction) and the MI group (15 with acute myocardial infarction).

All patients underwent coronary angiography during the acute or subacute stage of their disease. In the MI group, intracoronary thrombolytic therapy was performed in 11 of 15 patients, and residual significant coronary stenosis (>75% reduction in luminal diameter) was present in all 15 patients in the chronic stage of myocardial infarction.

BMIPP SPECT Imaging

BMIPP scintigraphy was performed 3–6 days after admission. The patients fasted after supper on the previous day. At rest, 185 MBq BMIPP (Nihon Medi-Physics Co., Nishinomiya, Japan; 2.27 Ci/mmol; volume, 1.5 ml) and 20 ml physiological saline were injected rapidly via the cubital vein while the patients lay on a SPECT bed. Two minutes later, five rounds of SPECT (dynamic SPECT) were performed in the continuous rotation mode, in which the three detector heads make an alternating motion in a 120° range with a cycle of 3 min (Fig. 1). A three-head gamma camera (GCA9300A/HG, Toshiba, Tokyo, Japan) was used in combination with a low-energy, high-resolution collimator. The energy window was set at 159 keV ± 10%, and the matrix was 64 × 64.

After dynamic data acquisition, conventional SPECT was taken 30 min after the BMIPP injection (30-min BMIPP). Conventional SPECT was acquired at intervals of 6° in a counterclockwise direction (view up from the foot). The 60 projection images were obtained for 40 sec/stop.

The SPECT projection data for 360° were processed with an image analyzer GMS5500A to reconstruct images. A Butterworth filter (cutoff frequency, 0.24 cycles/pixel; order 8) was the prefilter for dynamic SPECT images. Another setting of the Butterworth filter (cutoff frequency, 0.30 cycles/pixel; order 8) was used as a prefilter for conventional SPECT images. A Shepp and Logan filter was used as a reconstruction filter for all images.

Thallium-201 SPECT Imaging

Resting ^{201}Tl scintigraphy was performed at least 2 days (range 2–7 days; mean ± s.d., 3.3 ± 1.5 days) after BMIPP scintigraphy.

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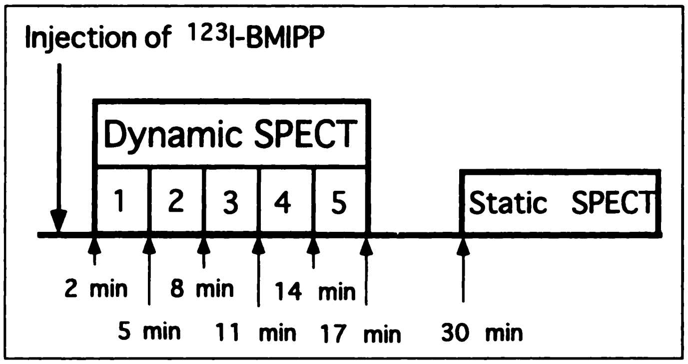


FIGURE 1. Protocol of BMIPP scintigraphy. BMIPP (185 MBq) and 20 ml physiological saline were injected rapidly via cubital vein. Two minutes later, five rounds of dynamic SPECT were performed in continuous rotation mode. Conventional SPECT was performed 30 min after injection.

Thallium-201 SPECT was performed and reconstructed using the same protocol as that used for conventional BMIPP SPECT. The energy window was set at 71 keV ± 10%.

Data Analysis

On the serial dynamic SPECT images, 30-min BMIPP images and resting ^{201}Tl images, the myocardium was divided into 14 segments (Fig. 2). The degree of tracer uptake in individual segments was classified visually on a 4-point scale (3 = normal; 2 = slightly reduced; 1 = moderately reduced; and 0 = severe defect) by two experienced, blinded observers. Differences were resolved by consensus.

The segmental uptake scores in early BMIPP (dynamic SPECT images taken from 2 min after injection), and 30-min BMIPP images were compared with those in the resting ^{201}Tl images in both groups of patients. When the ^{201}Tl uptake score was higher than the BMIPP uptake score, the segment was defined as mismatching. When the scores were the same, the segment was defined as matching. When the BMIPP uptake score was higher than the ^{201}Tl uptake score, the segment was defined as reverse mismatching.

In each of the patients, either one or no mismatching segments between resting ^{201}Tl and 2–5-min BMIPP images was regarded as concordant uptake in each patient. Two or more mismatching segments between the two images was regarded as discordant uptake.

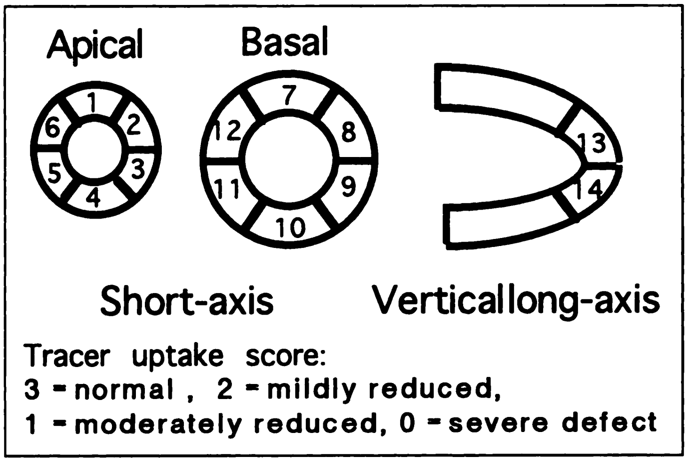


FIGURE 2. Visual interpretation of regional BMIPP and ^{201}Tl uptake. Basal and midventricular short-axis images were divided into 12 segments, and the vertical long-axis image was also divided into two apical segments. Territories of coronary arteries in left ventricle were defined as follows: left anterior descending artery territory = segments 1, 6, 7, 12, 13 and 14; right coronary artery territory = segments 4, 5, 10 and 11; and left circumflex coronary artery territory = segments 2, 3, 8 and 9.

In quantitative analysis, the percentage ^{201}Tl activity and the percentage BMIPP activity (30-min BMIPP image) for the maximum count of the left ventricle in the culprit lesion (mismatching or matching segment) were evaluated in the bull's-eye images. The Δ percentage ^{201}Tl-BMIPP activity in the culprit lesion was calculated by the following formula: % ^{201}Tl activity − % BMIPP activity = Δ % ^{201}Tl-BMIPP activity.

For the washout analysis, the BMIPP washout rate from the images taken 2–5 and 14–17 min on dynamic SPECT was assessed in the bull's-eye image. The BMIPP washout rate in the matching, mismatching or normal (matching segment in the normal coronary artery territory) area was determined in each of the patients. If the severe defect was observed in both the 2–5-min and the 14–17-min BMIPP images in the patients with acute myocardial infarction, the BMIPP washout rate was not calculated.

Image quality in the 2–5-min BMIPP image was evaluated as good, fair or poor. Maximum myocardial counts (counts per pixel) in 2–5-min BMIPP SPECT images were also evaluated.

Statistical Analysis

Data are presented as the mean ± s.d. The concordance of the uptake score between BMIPP and resting ^{201}Tl images was assessed using kappa statistics. Linear regression analysis was used to compare the BMIPP washout rate and the Δ percentage ^{201}Tl-BMIPP activity.

RESULTS

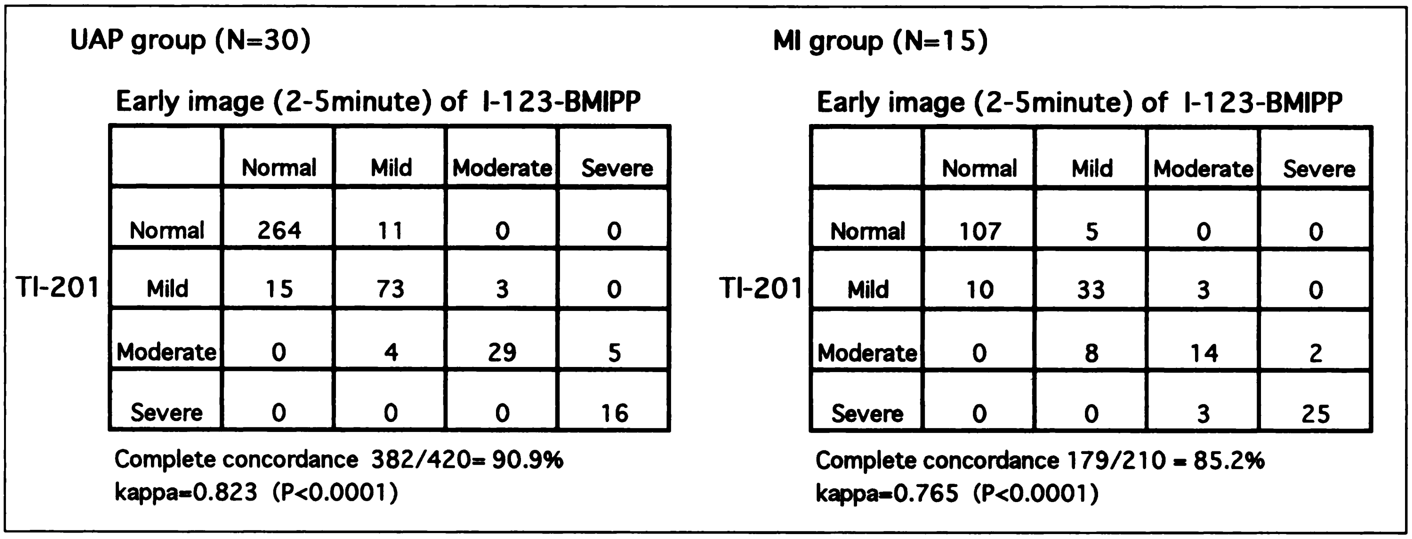
Comparison of 2–5-Minute and 30-Minute BMIPP Images with Thallium-201 Images

Figure 3 shows the segmental comparison of uptake score between early BMIPP (taken 2–5 min after injection) and resting ^{201}Tl images. The complete concordance rates between the two images were 90.9% and 85.2% in the UAP and MI groups, respectively. The kappa statistics of uptake score between early BMIPP and resting ^{201}Tl images showed good concordance in UAP ($\kappa = 0.823$, $p < 0.0001$) and MI ($\kappa = 0.765$, $p < 0.0001$) groups, respectively. Mismatching segment numbers between the early BMIPP and resting ^{201}Tl images were 19 and 10 in the UAP and MI groups, respectively. Reverse mismatching segment numbers between the two images were 19 and 21 in the UAP and MI groups, respectively. No myocardial segments showed two or more grades of difference in uptake score between early BMIPP and resting ^{201}Tl images.

Figure 4 shows a segmental comparison of uptake score between 30-min BMIPP and resting ^{201}Tl images. One hundred nine of the 420 segments in the UAP group and 38 of the 210 segments in the MI group showed a lower BMIPP uptake score than a resting ^{201}Tl uptake score (mismatching segment).

In the UAP group, mismatching segments between 30-min BMIPP and resting ^{201}Tl images were observed in 27 of 30 patients. Fatty acid metabolism was estimated as abnormal in 27 of 30 patients. The majority of the mismatching segments (96 of 109) in the UAP group were located in the culprit territory of angina pectoris, as determined by coronary angiography. In the MI group, mismatching segments between 30-min BMIPP and resting ^{201}Tl images were observed in 8 of 15 patients. Fatty acid metabolism was estimated as abnormal in 8 of the 15 patients in the infarct area.

Table 1 shows the mismatching segment summary between serial dynamic BMIPP and resting ^{201}Tl images in each patient. The smallest number of mismatching segments was observed between 2–5-min BMIPP and resting ^{201}Tl images. Twenty-eight of 30 patients in the UAP group and 13 of 15 patients in the MI group showed concordant tracer uptake between 2–5-min BMIPP and resting ^{201}Tl images. The number of mismatch-



UAP group (N=30)

Early image (2-5minute) of I-123-BMIPP

Tl-201	Normal	Mild	Moderate	Severe
Normal	264	11	0	0
Mild	15	73	3	0
Moderate	0	4	29	5
Severe	0	0	0	16

Complete concordance 382/420= 90.9%
kappa=0.823 (P<0.0001)

MI group (N=15)

Early image (2-5minute) of I-123-BMIPP

Tl-201	Normal	Mild	Moderate	Severe
Normal	107	5	0	0
Mild	10	33	3	0
Moderate	0	8	14	2
Severe	0	0	3	25

Complete concordance 179/210 = 85.2%
kappa=0.765 (P<0.0001)

FIGURE 3. Segmental comparison of tracer uptake between 2–5-min BMIPP and resting ^{201}Tl images.

ing segments was greatest between 14–17-min BMIPP and resting ^{201}Tl images.

Figure 5 shows the images from a typical patient with unstable angina pectoris. Mildly reduced uptake in the anterolateral area was observed in both the 2–5-min BMIPP and the resting ^{201}Tl images. However, BMIPP accumulation in the anterolateral area was gradually decreased in the serial BMIPP images. Thallium-201-BMIPP mismatch between 14–17-min BMIPP and resting ^{201}Tl images was evident in the anterolateral area. Figure 6 illustrates images from a patient with acute myocardial infarction. The large anteroseptal defect was observed in both the serial BMIPP and the resting ^{201}Tl images and was also clearly defined, as shown in the 2–5-min BMIPP images.

Quantitative Analysis

Table 1 shows the percentage ^{201}Tl activity, the percentage BMIPP activity, the Δ percentage ^{201}Tl-BMIPP activity and the BMIPP washout rate between the 2–5- and 14–17-min images in each patient. The Δ percentage ^{201}Tl-BMIPP activity in the mismatching or matching segments was 24.8% ± 9% (range 11–44) versus −1.3% ± 0.6% (range −2 to −1) in the UAP group and 16.6% ± 6% (range 10–27) versus 2.4% ± 4% (range −3 to 9) in the MI group, respectively.

The BMIPP washout rates between 2–5-min and 14–17-min images in the mismatching, matching and normal areas were 21.4 ± 17%, −12.6% ± 7% and −15.9% ± 5% in the UAP group and 19.9% ± 14%, −10.0% ± 6% and −13.0% ± 3% in the MI group, respectively. The BMIPP washout rate in the mismatching area was significantly higher than that in the matching or normal area in both groups of patients.

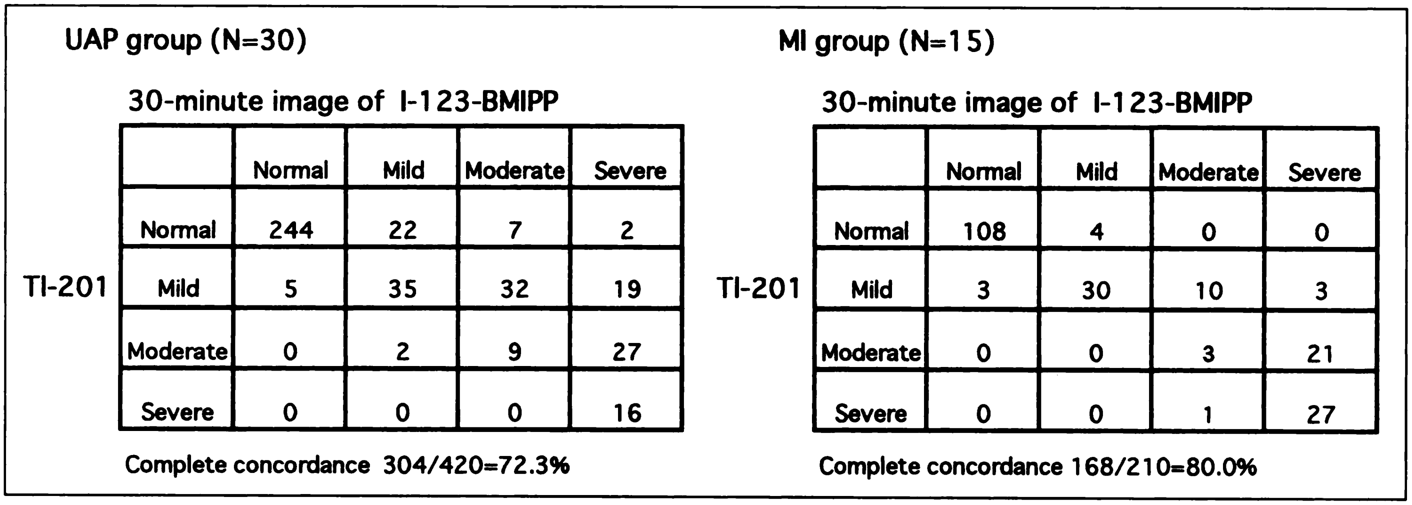
Figure 7 shows a relationship between the BMIPP washout rate and the Δ percentage ^{201}Tl-BMIPP activity in both groups of patients. A significant positive correlation between the two parameters was observed ($r = 0.65$, $p < 0.002$).

Image Quality in 2–5-Minute BMIPP Images

Table 2 shows the results of image quality in the 2–5-min BMIPP images. Four of 45 patients showed poor image quality. However, the majority of patients in both groups showed good or fair image quality. The degree of tracer uptake in individual segments could be classified visually in all patients. The maximum number of myocardial counts (counts per pixel) in the 2–5-min BMIPP SPECT image was 53.1 ± 12 (range 31–71).

DISCUSSION

BMIPP is used clinically to reflect myocardial fatty acid metabolism in patients with ischemic heart disease. Abnormal fatty acid metabolism has been estimated as mismatched tracer uptake between BMIPP and ^{201}Tl or sestamibi images (*1–10*). For the analysis of BMIPP images, resting ^{201}Tl or sestamibi images were always required, and BMIPP SPECT acquisition was usually initiated 15–20 min after BMIPP injection (*1–10*).



UAP group (N=30)

30-minute image of I-123-BMIPP

Tl-201	Normal	Mild	Moderate	Severe
Normal	244	22	7	2
Mild	5	35	32	19
Moderate	0	2	9	27
Severe	0	0	0	16

Complete concordance 304/420=72.3%

MI group (N=15)

30-minute image of I-123-BMIPP

Tl-201	Normal	Mild	Moderate	Severe
Normal	108	4	0	0
Mild	3	30	10	3
Moderate	0	0	3	21
Severe	0	0	1	27

Complete concordance 168/210=80.0%

FIGURE 4. Segmental comparison of tracer uptake between 30-min BMIPP and resting ^{201}Tl images.

TABLE 1
Mismatching Segment Summary Between Serial BMIPP and Resting Thallium-201 Images

Patient no.	Age (yr)	Sex	Vessels with CAD	Mismatching segment no. between resting ^{201}Tl and serial BMIPP images						Mismatching segment no. between 2–5-min BMIPP and resting ^{201}Tl images in each coronary territory			Concordance between 2–5-min BMIPP and ^{201}Tl images	BMIPP washout rate between 2–5-min and 14–17-min images			Culprit lesion		
				2–5 min	5–8 min	8–11 min	11–14 min	14–17 min	30 min	LAD	RCA	LCX		Matching	Mismatching	Normal	% BMIPP activity	% Tl activity	Δ Tl-BMIPP % activity
Angina pectoris group																			
1	61	M	1 LAD	1	3	6	6	6	6	1	0	0	○	—	11	−16	76	89	13
2	62	M	1 LAD	1	0	5	5	5	5	0	0	1	○	−13	12	−15	63	95	32
3	55	M	1 LCX	0	2	2	2	2	2	0	0	0	○	−13	26	−14	44	78	34
4	43	M	1 LAD	3	3	3	3	3	3	3	0	0	×	−14	−3	−15	74	94	20
5	56	M	2 RCA,LCX	0	1	2	2	2	2	0	0	0	○	−15	24	−14	45	73	28
6	60	M	2 LAD,RCA	1	6	6	8	8	8	0	0	0	○	−10	15	−11	57	78	21
7	65	M	2 LMT	0	0	2	2	2	2	0	0	0	○	−12	27	−13	37	81	44
8	58	F	3 L,R,X	0	0	6	6	6	6	0	0	0	○	−17	15	—	53	85	32
9	80	F	3 L,R,X	0	0	2	4	4	4	0	0	0	○	−11	25	—	49	81	32
10	66	F	2 LAD,RCA	2	2	2	2	2	2	2	0	0	×	−12	−2	−14	68	87	19
11	64	M	1 LCX	0	0	0	0	0	0	0	0	0	○	−15	—	−16	97	96	−1
12	54	M	2 LAD,RCA	1	6	7	8	8	7	1	0	0	○	−14	28	−16	39	73	34
13	56	M	2 RCA,LCX	0	1	2	2	2	2	0	0	0	○	−18	9	−19	53	82	29
14	71	M	1 LAD	0	0	2	2	2	2	0	0	0	○	−27	4	−30	59	81	22
15	50	M	1 RCA	0	0	2	2	2	2	0	0	0	○	−12	10	−12	50	61	11
16	70	M	3 L,R,X	1	1	1	1	3	3	1	0	0	○	−15	19	—	47	85	38
17	72	M	3 L,R,X	1	2	4	6	6	6	0	1	0	○	−8	32	—	55	77	22
18	55	M	3 L,R,X	0	0	2	2	2	2	0	0	0	○	−14	17	—	61	80	19
19	64	M	3 L,R,X	1	3	6	8	8	7	0	1	0	○	−16	39	—	31	73	42
20	65	M	2 LAD,RCA	1	6	10	11	11	11	1	0	0	○	—	60	−15	41	65	24
21	73	M	2 LAD,RCA	0	0	0	0	0	0	0	0	0	○	−21	—	−20	96	95	−1
22	35	M	3 L,R,X	0	1	1	1	1	1	0	0	0	○	1	69	—	50	68	18
23	71	M	3 L,R,X	1	3	4	4	4	4	0	0	0	○	−11	25	—	41	66	25
24	70	F	2 LAD,X	0	3	4	4	4	4	0	0	0	○	11	18	−11	62	85	23
25	68	M	1 RCA	1	3	4	4	4	4	0	1	0	○	—	11	−20	41	60	19
26	48	F	1 LAD	1	2	3	3	3	3	1	0	0	○	−9	37	−11	72	86	14
27	55	M	1 LAD	1	2	3	3	3	3	1	0	0	○	−18	10	−18	42	55	13
28	63	M	3 L,R,X	0	0	0	0	0	0	0	0	0	○	−13	—	—	75	73	−2
29	60	M	2 LAD,LCX	1	3	4	4	4	4	0	0	0	○	−11	38	−10	33	61	28
30	61	M	1 LCX	1	3	4	4	4	4	0	0	1	○	—	1	−24	67	81	14
Myocardial infarction group																			
1	68	M	1 LAD	1	1	1	1	1	1	1	0	0	○	*	4	−14	18	20	2
2	55	M	3 L,R,X	0	0	0	0	0	0	0	0	0	○	*	—	—	26	23	−3
3	63	M	1 LAD	1	2	2	3	3	3	1	0	0	○	−12	22	−15	35	52	17
4	47	M	2 LAD,RCA	0	4	4	5	5	5	0	0	0	○	−5	46	−11	37	64	27
5	75	M	2 LAD,RCA	2	3	6	6	6	6	0	2	0	×	−15	20	−16	39	61	22
6	61	M	1 LAD	2	3	4	4	4	4	1	1	0	×	−4	39	−8	59	72	13
7	63	M	1 LAD	1	1	1	1	1	1	1	0	0	○	*	11	−14	24	35	11
8	56	M	2 RCA,LCX	0	0	0	0	0	0	0	0	0	○	−16	—	−16	33	34	1
9	51	M	1 LAD	1	2	4	4	4	4	1	0	0	○	−13	9	−15	42	55	13
10	71	M	2 LAD,RCA	0	0	1	1	1	1	0	0	0	○	−14	5	−14	40	55	15
11	77	F	1 LAD	0	0	0	0	0	0	0	0	0	○	−10	—	−9	62	65	3
12	67	F	1 LAD	0	0	4	4	4	4	0	0	0	○	−7	23	−10	55	65	10
13	68	M	1 LCX	1	1	4	4	4	4	0	0	0	○	—	33	−14	41	64	23
14	63	F	3 L,R,X	1	3	4	4	4	5	1	0	0	○	−15	7	—	48	63	15
15	71	M	3 L,R,X	0	0	0	0	0	0	1	0	0	○	1	—	—	31	40	9

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*BMIPP washout rate was not calculated if the severe defect was observed both in the 2–5- and 14–17-min BMIPP images.

Concordance = no or only one mismatching segment between 2- and 5-min BMIPP and resting Tl images was regarded as concordant radioisotope uptake; M = male; F = female; LCX = left circumflex coronary artery; LMT = left main trunks; L,R,X = right, left descending and circumflex coronary artery; RCA = right coronary artery; LAD = left anterior descending coronary artery; 2–5-min = 2–5-min BMIPP image; 5–8-min = 5–8-min BMIPP image; 8–11-min = 8–11-min BMIPP image; 11–14-min = 11–14-min BMIPP image; 14–17-min = 14–17-min BMIPP image; ○ = concordant uptake; × = discordant uptake.

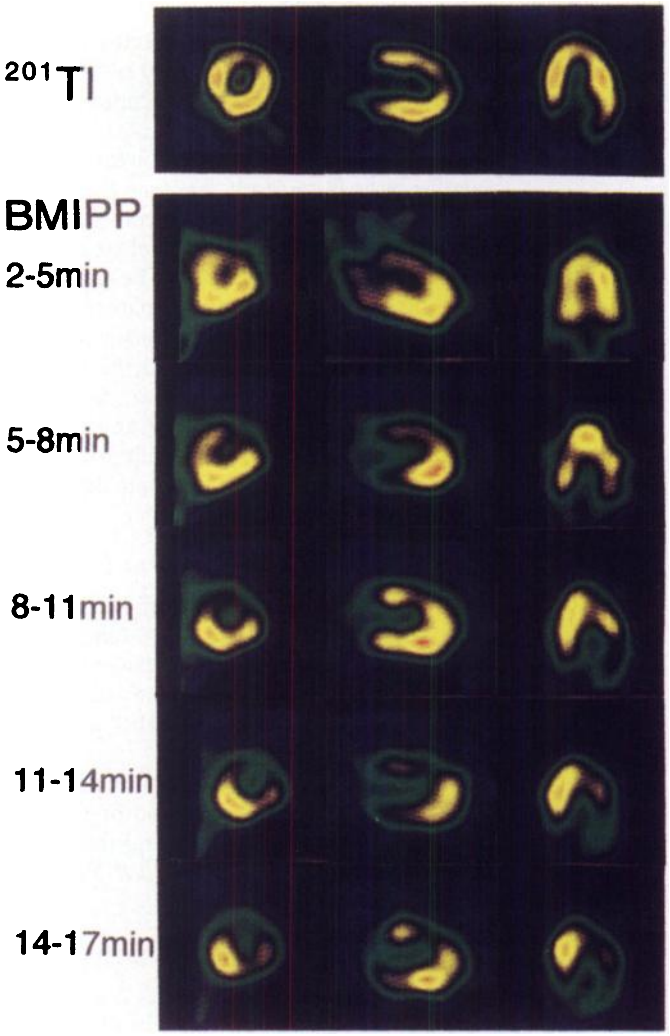

FIGURE 5. Resting ^{201}Tl and serial BMIPP images from patient with unstable angina pectoris. Coronary angiography showed significant coronary stenosis in left anterior descending and left circumflex artery. Mildly reduced uptake in anterolateral area was observed in both 2–5-min BMIPP and resting ^{201}Tl images. BMIPP accumulation in anterolateral area was gradually decreased in serial BMIPP images. Initial distribution of BMIPP accurately reflected myocardial perfusion imaging.

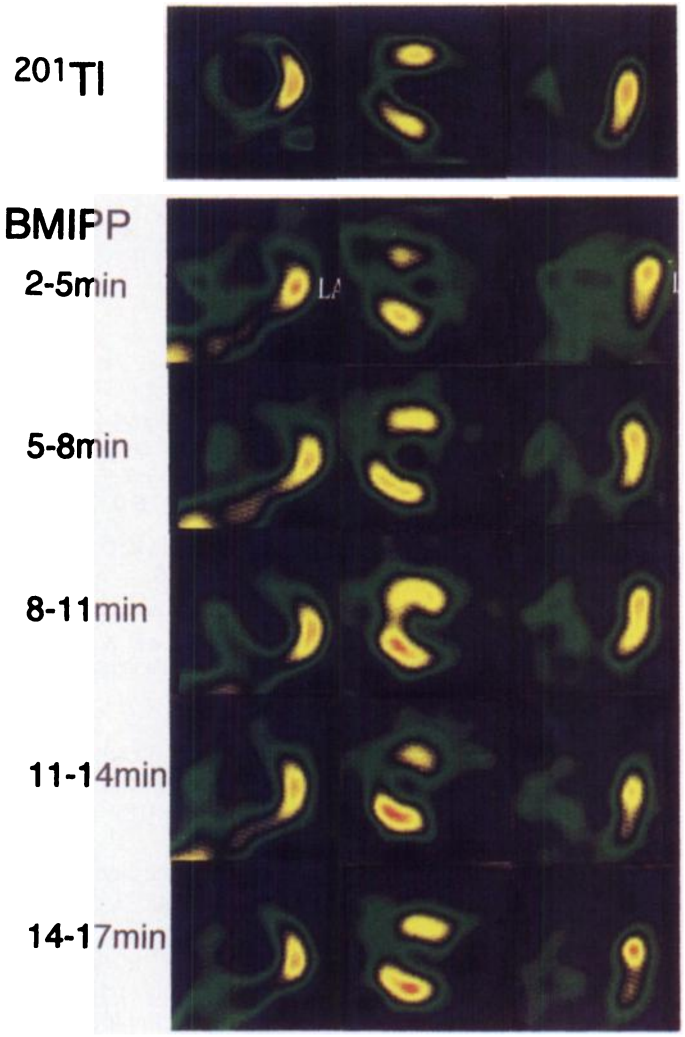

FIGURE 6. Resting ^{201}Tl and serial BMIPP images from patient with acute myocardial infarction. Large anteroseptal defect was observed in both serial BMIPP and resting ^{201}Tl images.

In this study, ^{201}Tl-BMIPP mismatch between 30-min BMIPP and resting ^{201}Tl images was observed in 27 of 30 patients in the UAP group and in 8 of 15 patients in the MI group, respectively. However, ^{201}Tl-BMIPP mismatch between early BMIPP and resting ^{201}Tl images was observed in only 2 of 30 patients in the UAP group and in only 2 of 15 patients in the MI group, respectively. These results indicated that initial distribution of BMIPP accurately reflects myocardial perfusion in patients with acute coronary syndromes.

We have shown that myocardial perfusion and fatty acid metabolism can be estimated simultaneously using a single dose of BMIPP when images are taken soon (2–5 min) and late (30 min) after the injection. This technique could be highly advantageous clinically because the current method of evaluating myocardial fatty acid metabolism requires a comparison of BMIPP and resting myocardial perfusion images (^{201}Tl or sestamibi images). The BMIPP dynamic SPECT technique can be applied for the detection of angina-related coronary territory in patients with unstable angina pectoris or for the evaluation of myocardial viability in patients with acute myocardial infarction without ^{201}Tl or sestamibi perfusion imaging.

In a few patients (four patients), however, tracer uptake was lower on the early BMIPP than on the resting ^{201}Tl images. Of these four patients, none of the myocardial segments showed a two-grade or greater difference in tracer uptake between the two images. These findings are probably due to the following factor(s):

1. BMIPP was washed out very quickly, and its uptake decreased during the first 2 min after injection; or
2. Resting myocardial blood flow differed between the acute (when BMIPP images were taken) and the subacute stages (when ^{201}Tl images were taken).

Myocardial perfusion in the culprit lesion might be improved when ^{201}Tl scintigraphy is examined. The period between BMIPP and resting ^{201}Tl scintigraphy in this study was 3.3 ± 1.5 days (2–7 days). The delay between BMIPP and ^{201}Tl scintigraphy may be one of the reasons why 2–5-min BMIPP and resting ^{201}Tl images differed in these four patients.

Early Kinetics of BMIPP

The BMIPP washout rate between 2–5-min and 14–17-min images in the ^{201}Tl-BMIPP mismatching area was significantly higher than that in the matching or normal areas. A significant positive correlation ($r = 0.65$, $p < 0.002$) was observed between the BMIPP washout rate and the Δ percentage ^{201}Tl-BMIPP activity, as shown in Figure 5. These results indicated that the degree of mismatching between 30-min BMIPP and ^{201}Tl images was significantly correlated to the amount of BMIPP backdiffusion.

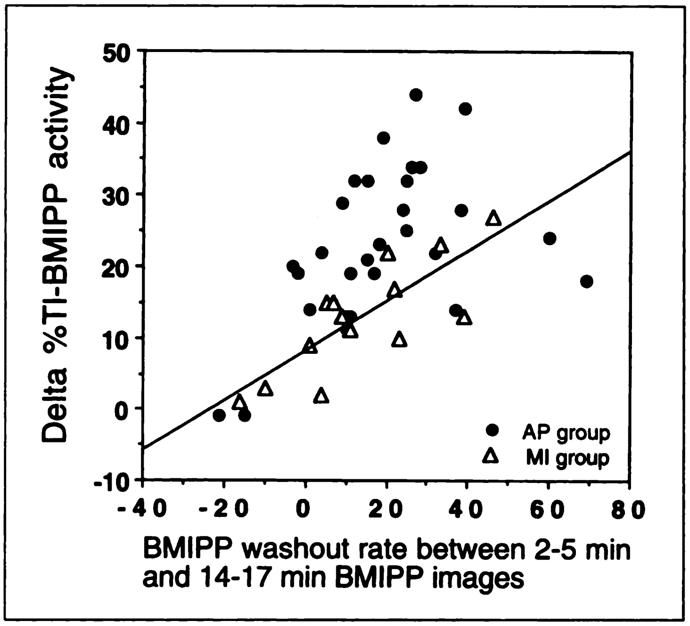

FIGURE 7. Correlation between BMIPP washout rate and Δ percentage ^{201}Tl-BMIPP activity. Significant positive correlation between the two parameters was observed ($r = 0.65$, $p < 0.002$).

The mechanism of BMIPP backdiffusion could suppress the conversion of BMIPP to BMIPP-coenzyme A in the metabolically impaired myocardium; therefore, free BMIPP cannot be retained in the myocardial cell (*11,12*).

In the normal area (matching segments in the normal coronary territory area), the BMIPP washout rate between the 2–5-min and 14–17-min images showed negative washout. There is a progressive accumulation of BMIPP in the normal myocytes (negative washout): energy-dependent activation to BMIPP-coenzyme A and subsequent storage in the intracellular lipid pool. In contrast, there is rapid washout due to backdiffusion (positive washout) in the myocytes with impaired fatty acid metabolism, resulting in a mismatch between BMIPP activity and flow tracer activity.

Optimal Acquisition Time

In this study, BMIPP SPECT acquisition was initiated 2 min after injection. This time point corresponds to the time when the first circulation of BMIPP through the body has been completed and BMIPP reaches the myocardium for the second circulation. It has been reported that blood concentration levels of BMIPP decrease rapidly after injection (*13,14*). To obtain myocardial images with low background radioactivity levels, it is desirable to begin imaging after blood BMIPP levels have decreased. However, the BMIPP uptake in the myocardium began to decrease soon (5–8 min) after injection, when BMIPP uptake was visually determined (Table 1). It is necessary to start imaging acquisition soon after BMIPP injection, which provides an opportunity to evaluate the initial distribution of BMIPP (myocardial perfusion imaging).

TABLE 2
Image Quality in 2-5-Minute BMIPP Images

	Good (%)	Fair (%)	Poor (%)
UAP group	13 (43)	15 (50)	2 (7)
MI group	6 (40)	7 (47)	2 (13)

Fair = fair image quality; good = good image quality; poor = poor image quality; UAP = unstable angina pectoris; MI = myocardial infarction.

Image Quality in Dynamic SPECT

In this study, 360° projection data were collected for 3 min, using a three-head gamma camera. The majority of the patients showed acceptable image quality for the evaluation of initial distribution of BMIPP.

However, the tracer radioactivity obtained with this technique (31–71 counts/pixel) was evidently less than that obtained with conventional SPECT. For this reason, the cutoff frequency of the prefilter was set at a slightly lower level (0.24 cycles/pixel) when images were reconstructed (*15*). The influence of decreasing tracer activity was assessed using a phantom model, based on the assumption that 4% of the administered BMIPP would be taken up by the myocardium. When the data were acquired within 2 min or less using a three-head detector, the image quality was became worse, and BMIPP activity in the phantom was uneven. When the data were acquired for 3 min, the image quality and reproducibility were acceptable (data not shown).

CONCLUSION

This study reports that initial distribution of BMIPP accurately reflects myocardial perfusion. Early (2–5-min) and late BMIPP image acquisitions will be highly advantageous because the current method of evaluating myocardial fatty acid metabolism always requires a comparison of late BMIPP and resting ^{201}Tl or sestamibi perfusion images.

Myocardial perfusion and fatty acid metabolism can be evaluated simultaneously with a single injection of BMIPP in patients with acute coronary syndromes by using the two-step acquisition technique, early at 2–5 min and late at 30 min.

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