

# **Risk Evaluation for Coronary Artery Disease in Patients with Impaired Glucose Tolerance after a Successful Coronary Intervention**

Running title: Endothelial dysfunction of CAD

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Mitsuaki Horigome, MD<sup>1</sup>, Naoya Hattori, MD, PhD<sup>2</sup>, Hiroki Kasai, MD, PhD<sup>1</sup>, Miki Horigome MD<sup>1</sup>, Shumpei Sakurai MD<sup>3</sup>, Kazuhiro Oguchi, MD, PhD<sup>4</sup>, and Uichi Ikeda, MD, PhD<sup>1</sup>

1) Department of Cardiovascular Medicine, Shinshu University Graduate School of Medicine, Matsumoto, Japan

2) Advanced Research Institute, Aizawa Hospital, Matsumoto, Japan

3) Department of Cardiovascular Medicine, Aizawa Hospital, Matsumoto, Japan

4) Department of Radiology, Aizawa Hospital, Matsumoto, Japan

## **Corresponding author:**

Naoya Hattori MD, PhD

Assistant Professor, Department of Molecular Imaging, Hokkaido University, Graduate School of Medicine

Kita 15 Nishi 7, Kita-Ku, Sapporo, Hokkaido, Japan

TEL: +81- 11-706-5152, Fax: +81-11-706-7155,

Email: nhattori@med.hokudai.ac.jp

## **First author:**

Mitsuaki Horigome, MD

Graduate student, Shinshu University Graduate School of Medicine

Department of cardiovascular medicine,  
National Hospital Organization, Matsumoto Medical center,  
2-20-30 Muraimachi minami, Matsumoto, Nagano, Japan  
TEL: +81-263-58-4567, FAX: +81-263-86-3183,  
Email: horigome@poem.ocn.ne.jp

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## ABSTRACT

**Purpose:** Patients with coronary artery disease (CAD) often have risk factors that may influence endothelial function. The purpose of this study was to evaluate the endothelial function and its association with coronary risk factors after percutaneous coronary intervention (PCI). **Materials and Methods:** Fourteen patients with impaired glucose tolerance (IGT) and CAD underwent positron emission tomography (PET) with N-13 ammonia to measure myocardial blood flow (MBF) at rest and during a cold pressor test (CPT) to estimate endothelial function as a percent increase (%increase) of MBF. The results were compared among normal segments (Normal), reperfused segments with PCI (PCI), and non-culprit CAD segments without PCI (Non-PCI). Correlations between the %increase and major risk factors were also investigated. **Results:** CPT induced significant increase in MBF in all groups. The %increase of Normal, Non-PCI, and PCI groups were  $33 \pm 22$  %,  $21 \pm 23$  %, and  $26 \pm 23$  %, respectively. Comparison with risk factors demonstrated significant correlations only in the Non-PCI group. Specifically, there were negative correlations between %increase vs. fasting blood sugar ( $r = -0.64$ ,  $p < 0.05$ ), HbA1c ( $r = -0.74$ ,  $p < 0.05$ ), total cholesterol ( $r = -0.87$ ,  $p < 0.05$ ), triglyceride ( $r = -0.71$ ,  $p < 0.05$ ), and LDL cholesterol ( $r = -0.92$ ,  $p < 0.005$ ), respectively. **Conclusions:** Although IGT patients with a PCI-treated coronary stenosis showed preserved response to CPT, the %increase negatively correlated with risk factors in the Non-PCI segments. Therefore, coronary risk factors may affect CAD lesions in PCI-treated patients.

## KEY WORDS

Positron Emission Tomography (PET)

Coronary Artery Disease

Impaired Glucose Tolerance (IGT)

Coronary Risk Factor

Endothelial Function

## INTRODUCTION

Endothelial dysfunction plays a role in the progression and clinical manifestation of atherosclerosis [1-3]. It is associated with risk factors in the absence of overt atherosclerosis [4], and is more pronounced in arteries with lesions responsible for acute coronary syndromes [5, 6]. Investigating the vascular response to a cold pressor test (CPT) in combination with imaging modalities is an established method for evaluating endothelial function [7, 8]. In particular, positron emission tomography (PET) using N-13 ammonia allows quantitative measurements of myocardial blood flow (MBF) [9, 10], which have been used to evaluate endothelial function as a %increase in MBF from rest to the CPT-induced stress condition [8, 11, 12].

Previous studies focused on early changes preceding atherosclerotic coronary artery disease (CAD) because severe endothelial dysfunction in the absence of obstructive CAD had been known to be associated with increased cardiac events [13-15]. Risk of patients who had already developed CAD has not been investigated, although another cardiac event may affect clinical outcome. In fact, modifications of cardiovascular risk factors improved patient outcomes disproportionately by improving coronary atherosclerosis [16]. From this point of view, we hypothesized that investigating endothelial function in a heart with known CAD would provide clinically relevant information for risk assessment. The purpose of this study was to investigate coronary endothelial function quantitatively by using positron emission tomography (PET) with N-13 ammonia in patients with known CAD and impaired glucose intolerance (IGT). In addition, correlations between endothelial function and coronary risk factors were investigated to provide information on the effectiveness of risk factor management to prevent cardiac events and further atherosclerotic changes.

## MATERIALS AND METHODS

### *Study Design*

All patients underwent dynamic PET scans using N-13 ammonia at rest and during CPT to quantitatively measure MBF at rest and in response to the cold stress. PET scans were scheduled within a month after percutaneous coronary intervention (PCI) to treat CAD (interval:  $22 \pm 9$  days). Individual quantitative results were summarized in 16 regional myocardial segments and were correlated with angiographic findings of post-interventional status (Normal, PCI, and Non-PCI) (Figure 1). In addition, the quantitative results were correlated with laboratory data of risk factors including the lipid and the glycemic profiles. The results of the PET scan were used for research purposes only, and were not used for treatment purpose. A human ethics committee at the Shinshu University School of Medicine, Matsumoto, Japan, approved the study procedures.

### *Subjects*

Patients were prospectively recruited from the population treated for CAD at the Shinshu University Hospital (Matsumoto, Japan). Between November 2005 and November 2007, 19 patients were recruited on the basis of the following inclusion/exclusion criteria: (1) patients with IGT as determined by fasting glucose level of less than 110 mg/dl and plasma glucose (2 h after breakfast) ranging from 140 to 200 mg/dl, (2) patients who had undergone PCI for treatment of stable/unstable angina without acute myocardial infarction, (3) patients who were not treated with an antidiabetic agent or insulin therapy or were not on diet/exercise therapy before receiving PCI, (4) patients without organic cardiac disease such as severe valvular disease, old myocardial infarction, cardiomyopathy, hypertensive heart disease, and symptomatic tachy- or brady-arrhythmia, (5) patients without familial hypercholesterolemia, heavy

smoking habits (>20 cigarettes/day), or significant hyperglycemia requiring antidiabetic agents, and (6) patients with multi-vessel disease, without chronic total occlusion. All subjects were screened for atherosclerosis obliterans (ASO) and cold-induced vasospasm at the time of scheduling for the PET scans to avoid possible complication during the stress procedures. The screening included an interview to confirm no intermittent claudication, and a measurement of Ankle Brachial pressure Index (ABI). According to the guideline for diagnosis of atherosclerosis obliterans, ABI from 1.00 to 1.29 was considered negative for ASO [17]. The cold-induced vasospasm was screened in the early morning (5:00 am) after PCI, using an electrocardiogram. Among 19 patients recruited, 14 consented to participate in the study. Table 1 summarizes the characteristics of the final study population.

#### *Treatment of coronary artery disease and percutaneous coronary intervention*

An institutional therapy guideline for CAD defines standard diagnostic and therapeutic procedures. This includes diagnostic work-up, including stress ECG, cardiac ultrasound, coronary angiogram, intensive medical treatment for coronary risk factors (i.e., hypertension, hyperlipidemia, smoking cessation), and low-dose aspirin (100 mg/day) and ticlopidine sodium hydrate (100 mg/day) as the standard antiplatelet therapy. The study protocol followed the guideline but included a PET scan as an additional diagnostic work-up. Diagnostic coronary angiography was performed in a standard fashion by using a Judkins technique and an intravenous injection of heparin (3000 U). In principle, angiographic procedures were performed with 4-Fr catheters via the transradial artery approach (TRA), while PCI was performed in a similar fashion but with a 5-Fr catheter. The TRA is a standard angiographic technique in our institution for both diagnostic and interventional procedures [18]. Clinically significant coronary stenosis was defined as stenosis  $\geq 75\%$  of the diameter. The results of the diagnostic angiogram were correlated with other diagnostic measures and patient's symptoms to identify culprit lesions that required interventional therapeutic approach. The therapeutic strategy employed a drug eluting stent (DES) (8 cases, 9 lesions), a bare metal stent (4 cases) or plain balloon angioplasty (3 cases, 4 lesions). In one patient with 2 lesions of dif-

ferent vessel diameters, the use of multiple devices (a drug eluting stent and a plain balloon angioplasty) was indicated to treat the culprit lesions.

### *PET study*

Figure 2 summarizes the acquisition protocol. The PET preparation required overnight fasting, blood sampling for the evaluation of coronary risk factors at the time of the PET scan, and then venous catheter insertion for radioisotope injection in one of the antecubital veins. All subjects refrained from caffeine, and alcohol, and smoking 24 h before the PET scan. Vasoactive medications, including calcium channel blockers, angiotensin converting enzyme inhibitors, statins, long-acting nitrates, and beta-blockers were withheld at least 12 h before the PET scan to avoid any drug-induced changes in hemodynamics during PET acquisition. All subjects underwent PET acquisition under the resting condition first and then under the stress condition with CPT. There was a period of 50 min between the rest and the stress scans to permit the tracer clearance. Each acquisition protocol consisted of a transmission scan for 10 min, followed by a dynamic emission scan in 2-dimensional acquisition mode, consisting of 20 frames ( $10\text{ s} \times 12$ ,  $30\text{ s} \times 6$ ,  $300\text{ s} \times 2$ ) starting at the time of N-13 ammonia injection. The dose of N-13 ammonia was 400 MBq for both the resting and the stress acquisitions. PET acquisition was done using a GE Advance NXi PET System (GE Healthcare, UK), which has 18 rings, yielding 35 contiguous transaxial slices with an axial field of view of 15.2 cm. The intrinsic spatial resolution was 4.2 mm at FWHM in the center of the field of view. The acquisition protocol for the stress protocol was identical to the resting protocol, except that a CPT started 1 min before administration of N-13 ammonia (Figure 2). The CPT lasted for 4 min by immersing one of the patient's foot and ankle in a tub containing a mixture of ice and water (temperature, 0–1°C). Systolic and diastolic blood pressure, heart rate, and electrocardiogram (ECG) were monitored continuously during the stress procedure.

For the quantitative PET analysis, the attenuation-corrected transaxial images were reconstructed with a filtered back-projection algorithm (Hanning filter, cut-off frequency 0.3 cycles per bin) and were forwarded to a personal computer for kinetic analysis by using a commercial software (PMOD version 2.75,

PMOD Technologies, Switzerland). A 2-compartment tracer kinetic model with metabolic correction was used to estimate regional MBF at rest and during stress conditions, respectively [19]. As reported previously, coronary endothelial function was defined as a %increase in MBF (from rest to stress condition), which was calculated using the following formula:  $\%increase = 100 (\%) \times (MBF_{stress} - MBF_{rest}) / MBF_{rest}$  [20].

### *Data Analysis*

The results of the quantitative analysis were summarized in a polar map consisting of 16 myocardial segments. In order to implement the individual variations in the coronary arterial supply, the angiographic findings were individually located on the polar map, rather than using a standard template based on a predictable relationship (Figure 1). The post-PCI coronary status was assessed for each major coronary artery (i.e., LAD, LCX, and RCA) according to the following 4 categories: (1) segments supplied by an artery with reperfused culprit lesions (PCI), (2) segments supplied by an artery with non-culprit stenoses, which had no PCI (Non-PCI), (3) segments supplied by an artery without significant stenosis (Normal), and (4) myocardial infarction. After excluding segments with myocardial infarction, segmental quantitative values were summarized on the basis of the post-PCI coronary status consisting of PCI, Non-PCI and Normal (Figure 1). In addition, correlations between the quantitative values and clinical markers of glucose metabolism were investigated and compared among the 3 post-PCI coronary statuses. Clinical markers included total cholesterol (T-CHO; mg/dl), LDL (mg/dl), HDL (mg/dl), and triglyceride (TG; mg/dl) for the lipid profile, and fasting blood sugar (FBS; mg/dl), hemoglobin A1c (HbA1c; %), immunoreactive insulin (IRI;  $\mu$ U/ml), and homeostasis model assessment of insulin resistance index (HOMA-R;  $IRI (\mu U/ml) \times FBS (mg/dl) / 405$ ) for the glycemic profile [21].

### *Statistics*

The results of quantitative parameters were expressed as mean  $\pm$  standard deviation (SD). Regional quantitative parameters were compared among post-PCI coronary statuses by using analysis of variance

(ANOVA). Stress-related changes in quantitative parameters were analyzed using a paired t-test. Correlations between the quantitative values and clinical markers of glucose metabolism were analyzed using Pearson's correlation coefficient. The level of statistical significance was set to be  $P < 0.05$  for all analyses.



## RESULTS

### *Metabolic parameters and other risk factors*

Table 1 summarizes patient characteristics and risk factors at the time of the PET scan. All lipid parameters were controlled to be lower than the optimum value recommended by the National Cholesterol Education Program [22], while glycemic parameters showed a mild abnormality. The study population showed no significant increase in insulin resistance as shown by normal HOMA-R and serum insulin levels. BMI and systolic blood pressure were mildly higher than the normal range, and the study population included 7 smokers. The smoking index was presented as a Brinkman index (number of cigarettes consumed per day multiplied by years of smoking) [23] (Table 1).

### *Coronary angiography and localization of stenotic vessels*

Table 2 summarizes the angiographic findings and coronary interventions. The results of the diagnostic coronary angiography revealed one-vessel disease in 3 patients, 2-vessel disease in 9 patients, and 3-vessel disease in 2 of 14 patients. Each patient had a culprit lesion of angina identified as a significant stenosis ( $\geq 75\%$ ) of a coronary artery without effective collateral circulation. Eleven culprit lesions were found in the LAD, 2 in the LCX, and 5 in the RCA. All culprit lesions were successfully reperfused with either balloon angioplasty (POBA) or coronary stent. Non-culprit stenoses (75%–90%), including 15 segments in the LAD, 23 in the LCX, and 0 in the RCA, were not reperfused and categorized as Non-PCI (Table 2). After mapping the above angiographic findings to the polar map display, reperfused segments by balloon angioplasty or stent (PCI) were labeled for 76/224 segments (34%), residual stenoses (Non-PCI) were labeled for 38/224 segments (17%), and normally perfused segments (Normal) were labeled for 110/224 segments (49%).

*Myocardial blood flow and %increase in MBF*

Table 3 shows the change in MBF at rest and during CPT among the 3 groups. There was no significant difference at rest, during CPT, and in the %increase in MBF among the 3 groups using ANOVA, although the Non-PCI segments tended to show lower MBF than the other groups ( $p = \text{n.s.}$ ). The CPT increased MBF in all 3 groups with %increase of  $33 \pm 22\%$  for Normal ( $p < 0.01$ ),  $22 \pm 24\%$  for Non-PCI ( $p < 0.05$ ), and  $26 \pm 23\%$  for PCI ( $p < 0.05$ ). The CPT increased hemodynamic parameters from the rest to the stress condition with the CPT (Table 4).

*Relationship between %increase in MBF and coronary risk factors*

Correlation analyses between %increase in MBF and major coronary risk factors demonstrated significant correlations only in the Non-PCI group. Normal and PCI groups did not show a correlation between %increase in MBF and any coronary risk factors. In the Non-PCI group, both parameters for glycaemic and lipid profiles demonstrated significant linear correlations (Figure 3, Figure 4). The r-value/p-value of the correlation analyses between %increase in MBF and each parameter were as follows:  $r = -0.64 / p < 0.05$  for FBS,  $r = -0.74 / p < 0.05$  for HbA1c,  $r = -0.87 / p < 0.05$  for T-CHO,  $r = -0.92 / p < 0.005$  for LDL,  $r = 0.49 / p = \text{n.s.}$  for HDL, and  $r = -0.71 / p < 0.05$  for TG.

## DISCUSSION

Quantitative measurements of regional MBF in IGT patients with recent history of coronary intervention demonstrated a similar pattern of endothelial function among regions containing Normal, PCI, and Non-PCI segments. However, regional endothelial function correlated differently with coronary risk factors among the 3 groups. Stenotic segments without intervention (Non-PCI) demonstrated correlations between %increase in MBF and coronary risk factors, while normal segments and segments that underwent PCI did not show any correlation.

Investigations of quantitative MBF using N-13 ammonia and PET have consistently reported coronary endothelial dysfunction in association with type 1 [24] and type 2 [25] diabetes, IGT [26], hypercholesterolemia [27], and smoking [28]. Impaired response to CPT has been considered as a reliable index of endothelial dysfunction, which precedes atherosclerotic coronary artery disease [29]. The previous studies, however, investigated endothelial function in segments without major stenotic lesions based on pre-test probability or exercise stress test. They focused on early changes preceding to coronary artery stenoses and did not investigate the endothelial function in the hearts that had already developed significant arterial stenosis. The present study differs from previous studies, because of the following reasons: (1) all patients underwent coronary angiography within 2 weeks of the PET scan and (2) all patients had at least 1 segment with significant coronary artery stenosis ( $\geq 75\%$  of the vessel diameter). This is a unique study focusing on the endothelial function in IGT patients with known coronary stenosis, who had undergone coronary intervention.

In our study population, resting MBF showed no significant difference among groups of treated (PCI), untreated (Non-PCI), and normal myocardial segments. For example, the resting myocardial perfusion in normal segments was  $0.73 \pm 0.18$  (ml/g/min), which was higher than the resting MBF previously reported for healthy normal subjects [26, 30] but was comparable to previously reported myocardial perfusion in 25 patients with IGT [26]. As reported previously, chronic hyperglycemia tends to increase MBF at rest, which may explain the mildly higher resting MBF in our study population [24, 30]. Similar resting MBF among Normal, Non-PCI, and PCI segments, probably indicating relatively small influence of clinical coronary arterial status on resting microvascular circulation. Unlike the resting MBF, it was expected that sympathetic stimulation with CPT would show different responses among the 3 post PCI status. However, CPT induced significant increases in MBF in all 3 groups although the %increase in PCI and Non-PCI segments were smaller than that in the Normal segments. In the present study, the Normal segments group showed a 33% increase in MBF, which was higher than the previously reported value in IGT patients with unknown coronary arterial status [26]. The preserved endothelial function in the Normal segments probably indicated the characteristics of the study population which included relatively early-stage of IGT patients with angiographically proven normal coronary status. The lack of difference in the response among the 3 groups was an intriguing finding considering the effect of PCI, which is essentially associated with vessel wall injuries and trauma to the coronary endothelium [31]. The small number of segments involved in our study may limit the statistical results. Further investigation should be done to clarify if the clinical status of coronary intervention influences endothelial dysfunction.

Another important finding in this study was the correlation between the regional endothelial function and the coronary risk factors. We found significant correlations between the %increase in MBF and the coronary risk factors in the Non-PCI segments, while the response did not correlate with any of the coronary risk factors in the Normal or in the PCI segments. In particular, endothelial function showed a significant negative correlation with LDL, suggesting the importance of lipid control for preserved endothelial function, which may prevent further development of atherosclerotic changes in the non-PCI segments. In this

study, PCI was performed only on culprit lesions, leaving other stenotic lesions to receive only conservative treatment without PCI. Since all non-PCI segments contained stenosis greater than 75% of luminal diameter, they were expected to have subclinical tissue ischemia. Previous study suggested subclinical ischemia may accelerate the formation of reactive oxygen species (ROS) by decreasing mitochondrial efficiency [32]. Our results support the above hypothesis by demonstrating significant correlations between endothelial function and coronary risk factors.

The major limitations of this study lie in the small number of patients involved, which might result in the homogeneous responses to the CPT among regions investigated. Another limitation of our study was related to the selection process, because we did not evaluate glucose metabolic function with an oral glucose tolerance test (OGTT), which is necessary for accurate diagnosis of IGT [33]. Instead of performing OGTT to diagnose IGT, our study protocol used FBS, HbA1c, and the postprandial blood sugar level for 2 h, which were done early after hospitalization as a standard therapeutic protocol in our institution. Since dietary intake during hospitalization was well controlled, this simplified test was clinically accepted for the assessment of coronary risk factors in our institution, although it might underestimate 2-h postprandial blood glucose levels compared with the OGTT.

Inclusion of 7 smokers in the study population might also affect the analyses. However, this study only enrolled the patients who quit smoking without nicotine-derived non-smoking aids. We also confirmed patients' non-smoking status periodically during PCI to PET scan. Average 22 days from PCI to the PET scan resulted in 34 days of nonsmoking status from the time of first visit to the PET scan. In fact, there was no significant difference in %increase of MBF between patients with ( $27 \pm 23$  %) vs. without ( $31 \pm 26$  %,  $p = \text{n.s.}$ ) prior smoking habits. Since coronary vasomotor abnormality is known to improve at 1 month after smoking cessation, the influence of smoking might be minimized [34].

Regarding the display system using a 16 segmental model, it should be noted that the system was based on the recommendations of the Subcommittee on Quantification of the American Society of Echocardiography Standard committee [35], which was implemented in the PMOD software [36]. Although recent similar studies generally employ a 17-segmental model, the difference in the display model will not influence the association between regional myocardial segments and supplying coronary arteries. The present study correlated regional myocardial segments with angiographic results to implement the variations in the coronary arterial supply, rather than simply stating the segments in their locations (e.g. anterior, lateral, inferior, septal and apex).

## CONCLUSION

Although IGT patients with a PCI-treated coronary stenosis showed preserved endothelial function in Normal, Non-PCI, or in PCI groups of the regional myocardial segments, the regional endothelial function negatively correlated with coronary risk factors in the segments with Non-PCI (residual CAD without PCI). In conclusion, coronary risk factors may affect CAD lesions in PCI-treated patients.

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## FIGURE LEGENDS

### Figure 1

A representative case with 2 stenotic lesions. A: Coronary angiogram demonstrated significant stenoses in LAD (90%, culprit, black arrow heads) and LCX (90%, white arrows). B: A same projection coronary angiogram after PCI to treat the culprit in the LAD. C: A schematic presentation of a polar map consisting of 16 left ventricular segments. After implementing individual variations in arterial blood supply, segments 7, 8, 13, 14 were grouped as “PCI”, segments 5, 6, 11, 12, 16 were grouped as “Non-PCI”, respectively. D: Result of angiographic correlations and segments grouping including PCI, Non-PCI, and Normal segments groups. Individual average of segments in each group was correlated with his/her coronary risk factors. RCA; Right Coronary Artery, LAD; Left Anterior Descending, LCX; Left Circumflex Artery.

### Figure 2

Study protocols. The rest-stress one-day PET protocol with N-13 ammonia. CPT; Cold Pressor Test.

### Figure 3

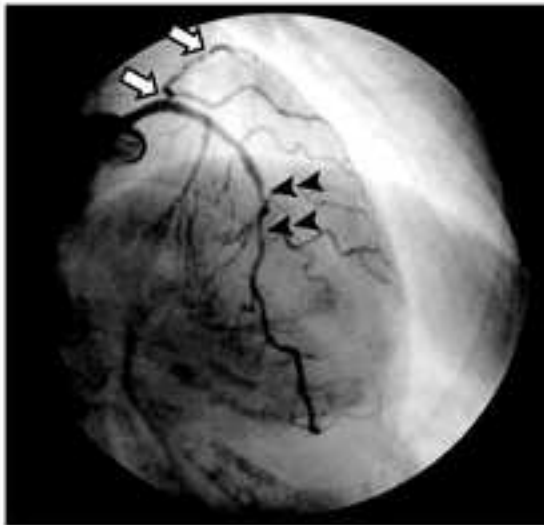
Correlations between glycemic parameters and %increase of MBF. Negative linear correlations were seen between %increase of MBF vs. FBS (A) and %increase of MBF vs. HbA1c (B).

### Figure 4

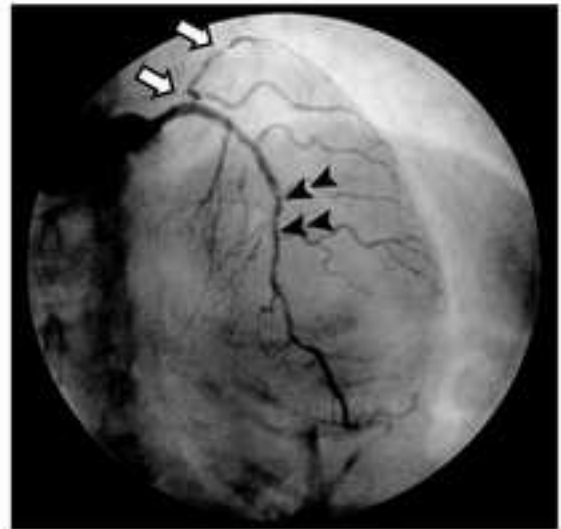
Correlations between serum lipid parameters and %increase of MBF. Negative linear correlations were seen between %increase of MBF vs. total-cholesterol (A), %increase of MBF vs. LDL-cholesterol(B),

and %increase of MBF vs. triglyceride (C). Correlation between %increase of MBF vs. HDL-cholesterol did not reach the level of statistical significance (D).

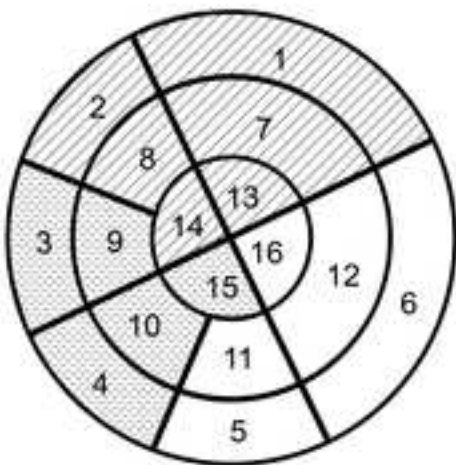
A.



B.

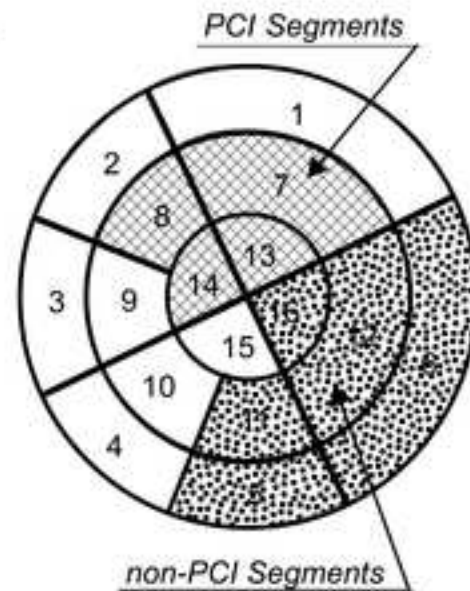


C.

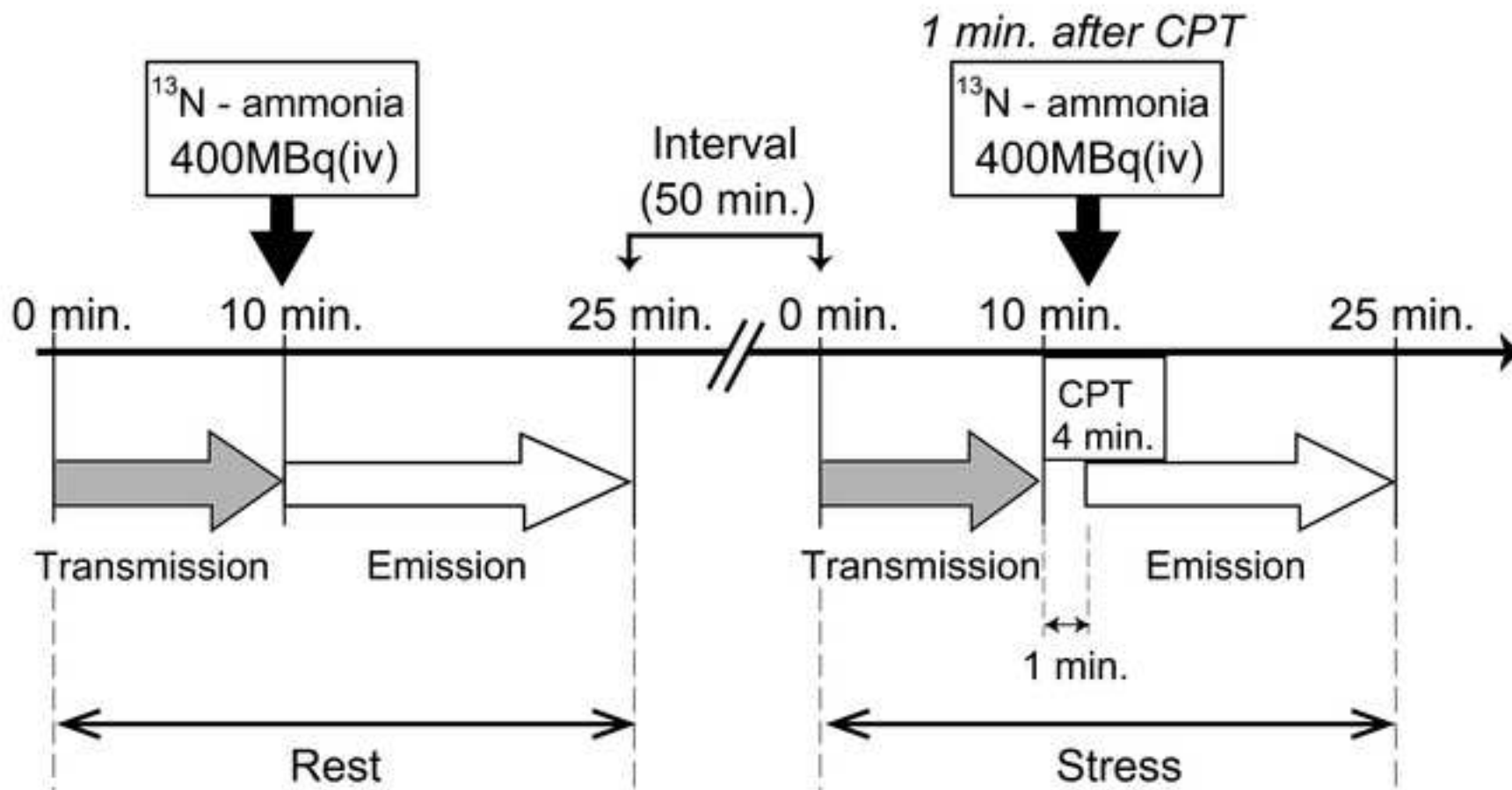


▨ LAD    □ LCX    ▨ RCA

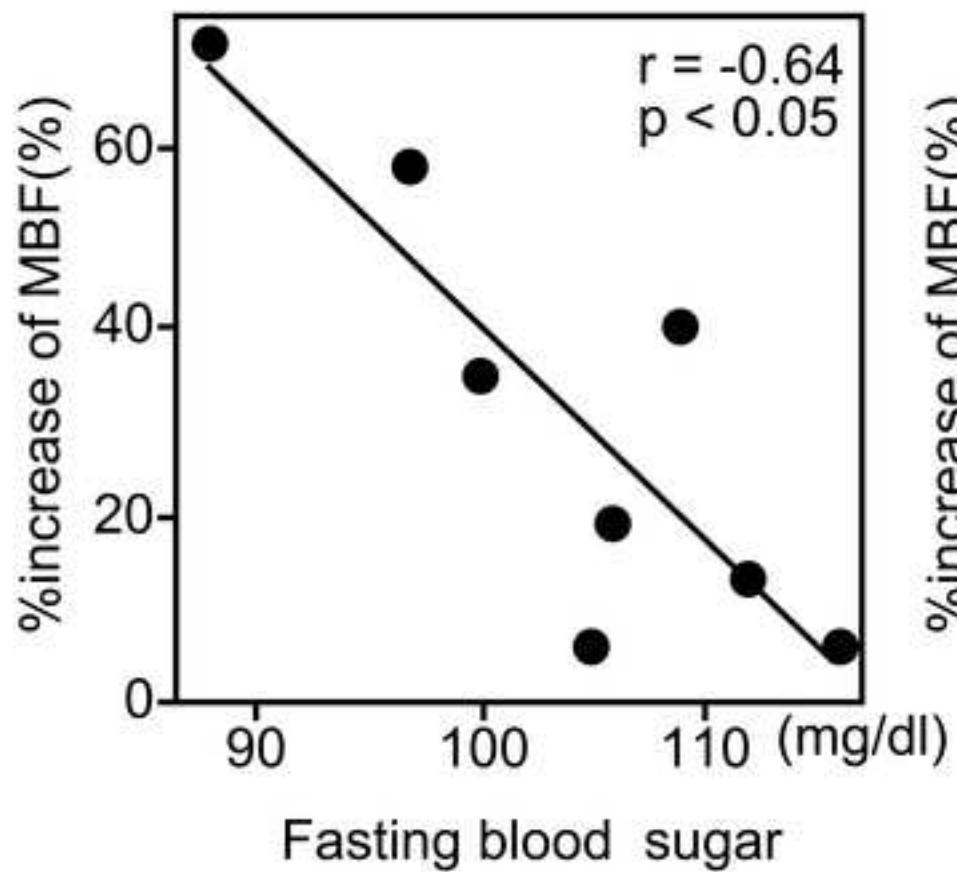
D.



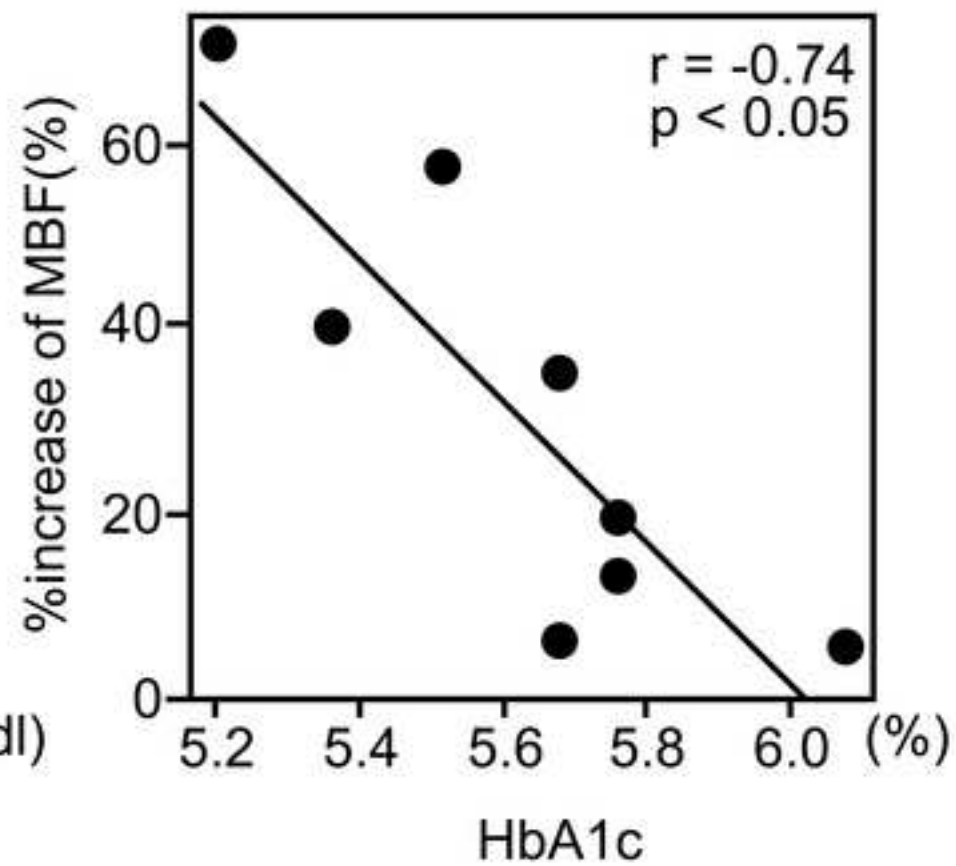
Other segments were regarded as NORMAL.



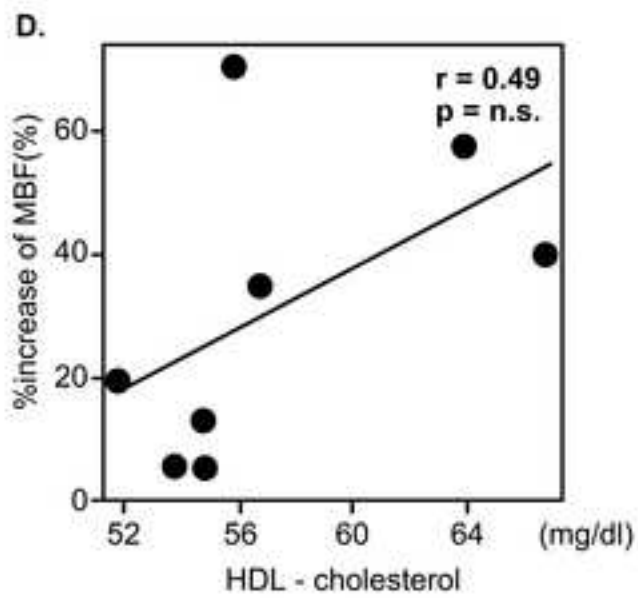
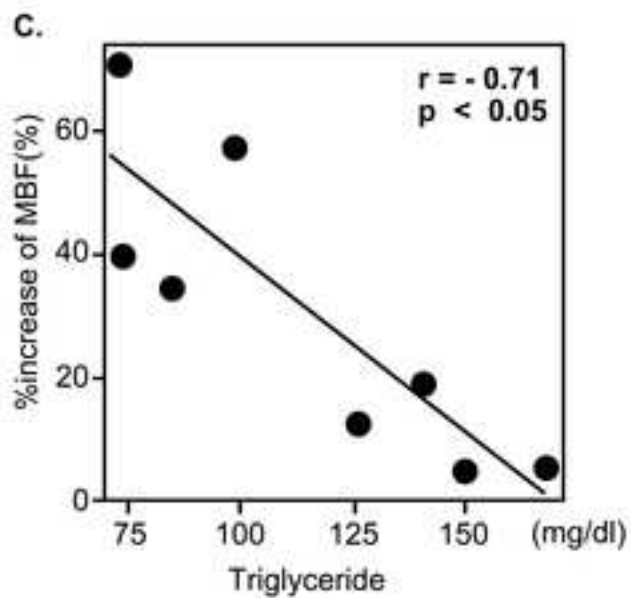
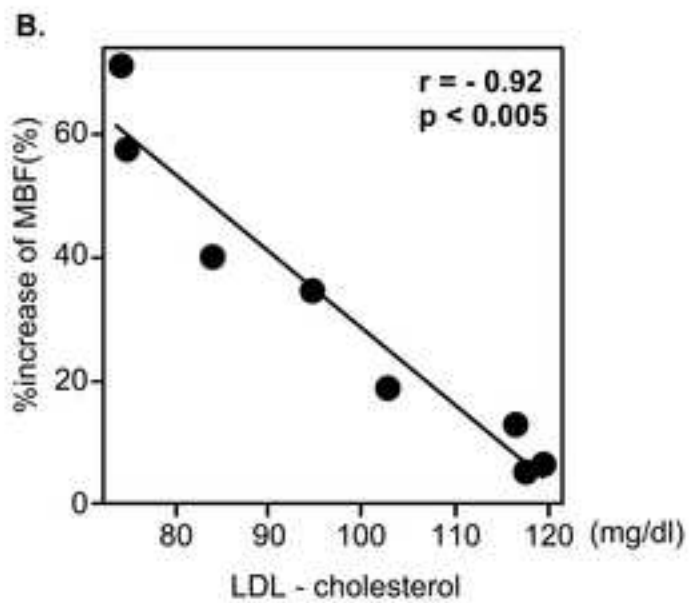
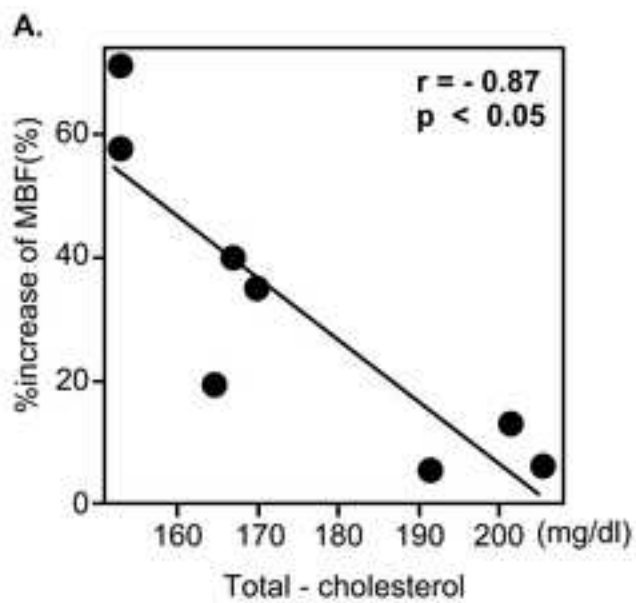
A.



B.







**TABLE 1.** Summary of Patient Characteristics at the Time of PET Scan.

Parameters	Mean $\pm$ SD	Unit	Reference
Total Cholesterol	167 $\pm$ 24	mg/dl	(150-219)
LDL-Cholesterol	92 $\pm$ 24	mg/dl	(70-139)
HDL-Cholesterol	55 $\pm$ 14	mg/dl	(40-86)
Triglyceride	111 $\pm$ 39	mg/dl	(50-149)
Phospholipid	198 $\pm$ 26	mg/dl	(160-260)
HbA1c	5.7 $\pm$ 0.5	%	(4.3-5.8)
Insulin	11.8 $\pm$ 3.5	$\mu$ U/ml	(3.06-16.9)
HOMA-R*	3.6 $\pm$ 0.9		(<2.4)
Fasting Glucose	124 $\pm$ 22	mg/dl	(70-109)
Body Mass Index	25.3 $\pm$ 2.6	kg/m <sup>2</sup>	(20-25)
Systolic Blood Pressure	135 $\pm$ 16	mmHg	
Diastolic Blood Pressure	80 $\pm$ 9	mmHg	
Brinkman Index	359 $\pm$ 457		

\*HOMA-R: Homeostasis Model Assessment for Insulin Resistance

**TABLE 2.** Summary of Angiographic Findings and Interventions. (n=14)

Patient No.	Prior Smoking	Culprit	Residual	Number of segments		
				Normal	non PCI	PCI
1	Yes	LAD 90%	LCX 75%	9	5	2
2	Yes	LAD 90%, LCX 90%	none	7	0	9
3	No	LAD 90%	LCX 90%	8	2	6
4	No	LAD 90%	LCX 90%	7	5	4
5	Yes	RCA 75%, LAD 90%	none	6	0	10
6	No	RCA 90%, LCX 75%	LAD 75%	4	6	6
7	No	LAD 90%	none	12	0	4
8	No	LAD 90%	none	10	0	6
9	Yes	RCA 90%, LAD 75%	LCX 75%	4	9	3
10	Yes	LAD 90%	none	10	0	6
11	Yes	RCA 90%	LAD 90%	9	4	3
12	No	LAD 90%	LCX 90%	12	2	2
13	No	LAD 75%	LCX 75%	7	5	4
14	Yes	RCA 90%, LAD 90%	none	5	0	11

LAD: Left Anterior Descending, LCX: Left Circumflex Artery, RCA: Right Coronary Artery

**TABLE 3.** Summary of Myocardial Blood Flow

		Normal	Non-PCI	PCI
Rest	(ml·g <sup>-1</sup> ·min <sup>-1</sup> )	0.73 ± 0.18	0.81 ± 0.15	0.75 ± 0.21
CPT	(ml·g <sup>-1</sup> ·min <sup>-1</sup> )	0.97 ± 0.22 <sup>**</sup>	0.97 ± 0.19 <sup>*</sup>	0.95 ± 0.29 <sup>*</sup>
% increase	(%)	33 ± 22	22 ± 24	26 ± 23

\* p < 0.05, \*\* p < 0.005 (rest vs. CPT)

CPT: Cold Pressor Test

**TABLE 4.** Hemodynamic Parameters

	Rest	during CPT
HR     min.	55.1 ± 6.3	62.1 ± 14.7 *
sBP   mmHg	135.6 ± 16.1	161.6 ± 22.3 **
dBp   mmHg	79.7 ± 8.9	90.4 ± 11.9 **
RPP   ( x100)	74.6 ± 12.0	101.9 ± 36.5 **

HR = Heart Rate; sBP = Systolic Blood Pressure

dBp = Diastolic Blood Pressure; RPP = Rate Pressure Product

\*: p<0.05 versus Rest, \*\*: p<0.005 versus Rest