

## 급성 심근경색증에서 경색심근의 관류상태와 관동맥 혈류예비능의 관계 및 혈류예비능의 변화

안정천 · 임도선 · 오영재 · 이호준 · 신성희 · 이은미 · 황교승  
송우혁 · 박창규 · 김영훈 · 서홍석 · 심완주 · 오동주 · 노영무

### Relation between Coronary Flow Reserve and Myocardial Perfusion State and Change of Coronary Flow Reserve in Acute Myocardial Infarction

Jeong Cheon Ahn, MD, Do Sun Lim, MD, Young Jae Oh, MD, Ho Jun Lee, MD,  
Sung Hee Shin, MD, Eun Mi Lee, MD, Kyo Seung Hwang, MD, Woo Heuk Song, MD,  
Chang Gyu Park, MD, Young Hoon Kim, MD, Hong Seog Seo, MD,  
Wan Joo Shim, MD, Dong Joo Oh, MD and Young Moo Ro, MD

Department of Internal Medicine, College of Medicine, Korea University, Seoul, Korea

#### ABSTRACT

**Background and Objectives** : The state of the coronary microcirculation is one of the major determinants of the prognosis of patients who have had successful reperfusion for acute myocardial infarction (AMI). We investigated whether the vasodilatory reserve in the infarcted myocardium correlated with the perfusion state at early recovery phase in 12 anterior wall AMI patients. **Materials and Method** : We measured coronary flow variables with Doppler wire, after successful revascularization by PTCA within 2 weeks following AMI and 13  $\pm$  0.5 months later, in the infarct related artery of AMI pts who received successful thrombolytic therapy. Myocardial perfusion state was evaluated by semiquantitative method (opacification score and opacification index) with myocardial contrast echocardiography (MCE) at the same time. Patients were divided into two groups according to initial perfusion status (perfusion defect group (PD (+), n = 7), no-perfusion defect group (PD (-), n = 5)). **Results** : 10 minutes after completion of the intervention, the coronary flow reserve (CFR) was  $2.0 \pm 0.4$  (mean  $\pm$  SD) ; it increased to  $2.7 \pm 0.7$  (p = 0.002) at follow up. The difference of initial CFR was not significant between PD (+) and PD (-) group. However, it significantly improved in the PD (-) group compared to PD (+) group at follow up ( $3.19 \pm 0.39$  vs.  $2.39 \pm 0.7$ , p = 0.046). Opacification index and initial CFR were significantly correlated (r = 0.79, p < 0.05). **Conclusion** : The perfusion state of infarcted myocardium was significantly correlated with coronary flow reserve in anterior wall AMI and CFR was significantly improved in patients with relatively preserved myocardial perfusion. (Korean Circulation J 1999;29(12): 1289-1296)

**KEY WORDS** : AMI · Coronary flow reserve · Myocardial perfusion.

: 1999 4 6  
: 1999 11 18  
: , 152 - 703 80  
: (02) 818 - 6633 · : (02) 866 - 1643  
E - mail : hhansin@unitel.co.kr

## 서 론

analization)  
(rec -  
(no - reflow  
phenomenon')  
(reperfusion injury)  
1)2)

25% (myoca -  
rdial contrast echocardiography)  
3) (myocardial pe -  
rfusion status)  
tion abnormality)  
(viability) 가 . 3)4)

가 가  
가 PET(positron emi -  
ssion tomography), MRI(magnetic resonance ima -  
ging), MCE(myocardial contrast echocardiogra -  
phy) 가  
가

Doppler wire

가 (coronary intervention)  
(decision - making process)  
Doppler wire  
(coronary flow reserve, CFR)

가 . 5) 6)

가

13 ± 0.5

## 재료 및 방법

대 상  
12  
ST  
(left anterior decending coronary art -  
ery)

12 ( : =10 : 2) 48 ±  
10.1 . 1 , 6

11 (11.3 ± 1 )

10 stent  
(residual stenosis) 10%  
stent

0.014 inch Doppler  
wire(FloMap, cardiometrics, Mountain View, CA,  
USA)  
13 ± 0.5  
(resteno -  
sis)

Doppler Wire를 이용한 관동맥 혈류지표의 측정

(n=2) stent (n=10) , 13.2 ± 5  
Doppler wire

(APV ; average peak velocity),  
(PDV ; peak diastolic velocity, PSV ;  
peak systolic velocity), / (DSVR ;  
Diasltolic - systolic velocity ratio)  
adenosine 18ug 20  
(coronary flow  
reserve, CFR) APV adenosine  
APV (baseline/adenosine average pe -  
ak velocity ratio)

심근 조영술(Myocardial contrast echocardiography)

p 0.05

Hewlett - Pakard 2.5  
MHz 1/2 inch

## 결 과

경색관동맥의 기저혈류 변화양상 및 혈류예비능의 변화

4 2 so -  
nicated Hexabrix 4 cc,  
3 cc

2.0 ± 0.4 2.7 ± 0.7 가  
(p = 0.002). (PDV)

4  
5 , 2 2 (DSVR)

(PSV), /

(APV)

가

가

( : 1 ,

(Table 1).

adenosin

PDV

0 ,

PSV, APV

가

0.5 ),

(p < 0.05).

(Opacification Index, OI)

통 계

PC - SPSS program

mean ± SD

doppler

paired t - test

normality

test paired t test

singed ra -

nked test

(median)

unpaired t test

normality

test

0.05

ranked sum test

doppler

(pearson's correlation)

(re -

gression analysis)

가

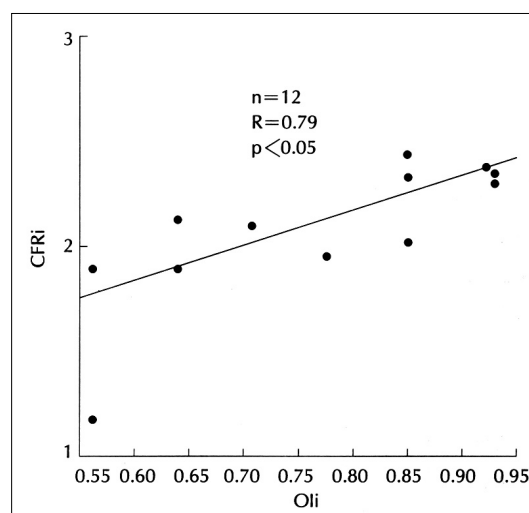


Fig. 1. Relation between CFR and OI.

CFR : coronary flow reserve,

OI : opacification index, i : initial

Table 1. Changes of doppler parameters

	PDV	PSV	APV	DSVR	CFR*
• Baseline (n=12)	35.2 ± 8.1	12.4 ± 6.6	18.1 ± 4.7	3.3 ± 2.0	2.0 ± 0.4
• FU	40.5 ± 16.7	15.8 ± 8.5	20.7 ± 8.5	2.8 ± 1.0	2.7 ± 0.7
	PDVa*		APVa*		APVa*
• Baseline (n=12)	65 ± 17.6		25.7 ± 6.8		36.3 ± 8.7
• FU	110.3 ± 47.4		48.7 ± 27.8		57.8 ± 28.6

FU : follow up,

PDV : peak diastolic velocity (cm/sec),

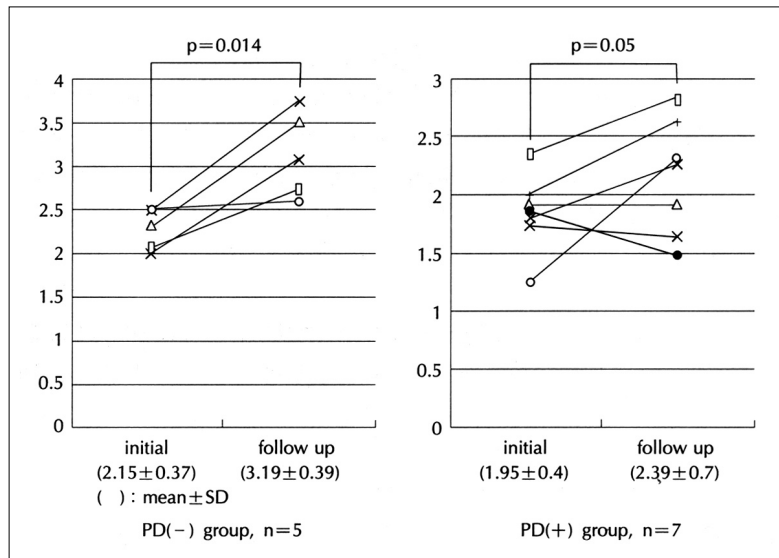
APV : average peak velocity (cm/sec),

\*p < 0.05 between baseline and follow up

a : after adenosine intracoronary injection

PSV : peak systolic velocity (cm/sec)

CFR : coronary flow reserve



**Fig. 2.** Change of CFR according to initial perfusion status.

경색심근의 관류상태에 따른 혈류지표의 변화

$r = 0.79$   
(Fig. 1).

2

가 0  
(perfusion defect group, PD(+))

가 0.5 1  
(non-perfusion defect group, PD(-))

12

7 , 5  
, Adenosine ,

가

Adenosine

(APV) PD(+)  $18.6 \pm 3.5$  cm/sec, PD(-)  $17.6 \pm 6.4$  cm/sec( $p=0.74$ )

Adenosine  $32.3 \pm 4.8$  cm/sec, 가 PD(+) 2.39

$42.0 \pm 10.3$  cm/sec( $p=0.05$ )  $\pm 0.7$ , PD(-)  $3.19 \pm 0.4$ ( $p=0.046$ )

Adenosine APV

(median, Mann-Witney rank sum test) PD

(+) PD(-) 20 cm/sec, 19 cm/sec

Adenosine 53.1 cm/sec, 64.2

cm/sec 가 ( $p>0.05$ ). PD(+) CFR  $1.95 \pm 0.4$

**Table 2.** Comparison of hemodynamic and doppler parameters according to perfusion state

	PD (-), n=5	PD (+), n=7	P
Age	50.6 $\pm$ 10.4	46.6 $\pm$ 10.5	NS
FUM	13.0 $\pm$ 6.2	13.6 $\pm$ 4.5	NS
HRb	72.0 $\pm$ 8.7	74.3 $\pm$ 8.8	NS
HRa	77 $\pm$ 9.2	81.1 $\pm$ 11	NS
iAPVb	17.6 $\pm$ 6.4	18.6 $\pm$ 3.55	NS
iAPVa	42.0 $\pm$ 10.3	32.3 $\pm$ 4.8	0.052
fAPVb#	19.0	20	NS
fAPVa	64.2 $\pm$ 34.3	53.1 $\pm$ 25.8	NS
iCFR	2.15 $\pm$ 0.37	1.95 $\pm$ 0.4	NS
fCFR	3.19 $\pm$ 0.39	2.39 $\pm$ 0.7	0.046*

FUM : follow up months, HR : heart rate, APV : average peak velocity(cm/sec), CFR : coronary flow reserve, l : initial, f ; follow up, b : before adenosine, a : after adenosine, PD (-) : no-perfusion defect group on contrast echocardiography, # : Mann-Witney test, PD (+) : perfusion defect group on contrast echocardiography, \* $p<0.05$

2.39±0.7 가 PD  
 (-) 2.15±0.37 3.19±0.39, p=0.014 12  
 가 (Fig. 2). ( 11.3±1 ) Doppler wire

## 고 안

13±0.5  
 Doppler wire  
 (collateral circulation), (re -  
 canalization) .<sup>7)8)9)</sup> Adenosin 가  
 가 (SPV) (DPV),  
 (APV)가 가  
 2.0 2.72  
 (microcirculation) 가 . Tsunoda<sup>14)</sup>  
 (ischemia) (reperfusion injury)  
 18 APV 4  
 (no reflow phenomenon) APV가  
 가 APV가 가  
 (spa -  
 sm), (en -  
 odthelial dysfunction) . Neuman<sup>5)</sup>  
 2  
 Cobb<sup>15)</sup> canine model  
 가  
 (contractile reserve) 가  
 Doppler wire spectral peak velocity  
 (absolute flow)  
<sup>16)17)</sup> 가  
 APV 가, 가  
 가  
 . Doppler wire  
<sup>11)</sup> <sup>12)</sup>  
<sup>13)</sup>  
<sup>5)</sup>  
 Doppler wire (colla -  
 teral circulation) ,  
 (flow reserve capacity),<sup>18)</sup>  
<sup>19)20)</sup>  
 가 ,

(occlusion)  
(blood stasis),<sup>20)</sup>

22)  
Kochi<sup>24)</sup>

21)  
23)

skinesia  
가

akinesia,  
가

hpokinesia  
.

va -  
CFR  
가

cuolar degeneration  
가

가

가

가

연구배경 :

가

가

13 ± 0.5

가

가

가

가 PET,  
scintigraphy, MCE  
가

2  
APV  
Doppler wire  
가

PD( - )  
Adenosine  
PD( + )  
가

가

PD( - )

가

가

방법 및 대상 :

12  
± 1 )  
가  
PTCA  
enosine 18 ug  
sonicated hexabrix  
1, 0.5, 0  
(OI)  
13 ± 0.5

연구의 제한점

2

결 과 :

1)  
dy -  
CFR  
2.72 ± 0.7 (p = 0.002)  
2.0 ± 0.4

가 CFR 이  
( $r=0.79$ ,  $p<0.05$ ).  
12  
(PD(+)) 7  
(PD(-)) 5 PD(+)  
PD(-) CFR 가  
PD(+)  
2.39±0.7, PD(-) 3.19±  
0.4  
2) PD(+)  
가 (1.94±0.4 vs. 2.39±0.7),  
PD(-) 가 (2.15±0.37 vs.  
3.19±0.39).  
결 론 :  
가  
PTCA Doppler  
wire CFR  
CFR  
중심 단어 :

## REFERENCES

- 1) Kitsum H, Iwama T, Kubo T, et al. No-reflow phenomenon during percutaneous transluminal coronary angioplasty. *Am Heart J* 1988;116:211-5.
- 2) Morishima I, Sone T, Mokuno S, et al. Clinical significance of no-reflow phenomenon observed on angiography after successful treatment of acute myocardial infarction with percutaneous transluminal coronary angioplasty. *Am Heart J* 1995;130:239-43.
- 3) Ito H, Tomoka T, Sakai N, Yu H, Higashino Y, Fujji K, et al. Lack of myocardial perfusion immediately after successful thrombolysis: A predictor of poor recovery of left ventricular function in acute myocardial infarction. *Circulation* 1992;85:1699-705.
- 4) Brochet E, Czitrom D, Karila-Cohen D, Seknadji P, Farraggi M, Benamer H, et al. Early changes in myocardial perfusion patterns after myocardial infarction: Relation with contractile reserve and functional recovery. *J Am Coll Cardiol* 1998;32:2011-7.
- 5) Neuman FJ, Kosa I, Dickfeld T, Blasini R, Gawaz M, Hausleiter J, et al. Recovery of myocardial perfusion in acute myocardial infarction after successful balloon angioplasty and stent placement in the infarct-related coronary artery. *J Am Coll Cardiol* 1997;30:1270-6.
- 6) Lim DS, Kim YH, Lee HS, Lim HE, Kim BH, Lee SJ, Park CG, Seo HS, Shim WJ, Oh DJ, RO YM, et al. Relation between Perfusion Status of Dysfunctional Myocardium and Coronary Flow Reserve in Acute Myocardial Infarction. *The Korean Circulation Journal* 1998;28:164-72.
- 7) Stacks RS, Philips HR III, Gierson DS. Functional improvement of jeopardized myocardium following intracoronary streptokinase infusion in acute myocardial infarction. *J Clin Invest* 1983;72:84-5.
- 8) Erlebacher JA, Weiss JL, Weisfeldt ML, Bulkeley MB. Early dilatation of the infarcted segments in acute transmural myocardial infarction: Role of infarct expansion in acute ventricular enlargement. *J Am Coll Cardiol* 1984;4:201-8.
- 9) Hochman JS, Choo H. Limitation of myocardial infarct expansion by reperfusion independent of myocardial salvage. *Circulation* 1987;75:299-306.
- 10) Bolognese L, Antoniucci D, Bunamici P, Cerisano G, Santoro GM, Marini C, et al. Myocardial contrast echocardiography versus dobutamine echocardiography for predicting functional recovery after acute myocardial infarction treated with primary coronary angioplasty. *J Am Coll Cardiol* 1996;28:1677-83.
- 11) Ofili EO, Kern MJ, Lavovitz AJ, St. Vrain JS, Segal J, Arguirre FV, et al. Analysis of coronary blood flow velocity dynamics in angiographically normal and stenosed arteries before and after endolumen enlargement by angioplasty. *J Am Coll Cardiol* 1993;21:308-16.
- 12) Anderson HV, Kirkeeide RL, Krishnaswami A, Weigelt LA, Revana M, Weisman HF, et al. Cyclic flow variations after coronary angioplasty in humans: Clinical and angiographic characteristics and elimination with 7E3 monoclonal antiplatelet antibody. *J Am Coll Cardiol* 1994;23:1031-7.
- 13) Deychak YA, Segal J, Reiner JS, Rohrbeck SC, Thompson MA, Lundergan CF, et al. Doppler guide wire flow velocity indexes measured distal to coronary stenosis associated with reversible thallium perfusion defects. *Am Heart J* 1995;129:219-27.
- 14) Tsunoda T, Nakamura M, Wakatsuki T, Nishida T, Asahara T, Anazi H, et al. The pattern of alteration in flow velocity in the recanalized artery is related to left ventricular recovery in patients with acute infarction and successful direct balloon angioplasty. *J Am Coll Cardiol* 1998;32:338-44.
- 15) Cobb FR, Bache RJ, Greenfield JR Jr. Regional myocardial blood flow in awake dog. *J Clin Invest* 1974;53:1618-25.
- 16) Doucort JW, Corl Payne HM, et al. Validation of Doppler guide wire for intravascular measurement of coronary artery flow velocity. *Circulation* 1992;85:1899-911.
- 17) Segal J, Kern MJ, Scott NA, et al. Alteration of phasic coronary artery flow velocity in human during percutaneous coronary angioplasty. *J Am Coll Cardiol* 1992;20:276-86.
- 18) Suryapranata H, Zijlstra F, MacLeod DC, et al. Predictive value of reactive hyperemic response on reperfusion on recovery of regional myocardial function after coronary angioplasty in acute myocardial infarction. *Circulation* 1994;89:1109-17.
- 19) Christian TF, Schwartz RS, Gibbons RJ, et al. Deter-

- minants of infarct size in reperfusion therapy for acute myocardial infarction. *Circulation* 1985;71:1121-8.
- 20) Engler RE, Schmidt-Schonbein GW, Pavelec RS, et al. Leucocyte capillary plugging in myocardial ischemia and reperfusion in the dog. *Am J Physiol* 1983;111:98-111.
  - 21) Powers ER, DiBona DR, Powell WJ, et al. Myocardial cell volume and coronary resistance during diminished coronary perfusion. *Am J Physiol* 1984;247:467-77.
  - 22) Hellstorm HR. The injury-spasm (ischemia-induced hemostatic vasoconstrictive) and vascular autoregulatory hypothesis of ischemic disease. *Am J Cardiol* 1982;49:802-10.
  - 23) Piana RJ, Paik GY, Mosucci M, et al. Incidence and treatment of no-reflow after percutaneous coronary intervention. *Circulation* 1994;89:2514-8.
  - 24) Sakabe K, Waskatsuki T, Shinohara H, Ikata J, Hiroyuki F, Oishi Y, et al. Coronary flow velocity patterns immediately after reperfusion reflect the pathologic characteristics of reperfused myocardium in canine models of acute myocardial infarction. *Coronary Artery Dis* 1998;9:21-7.