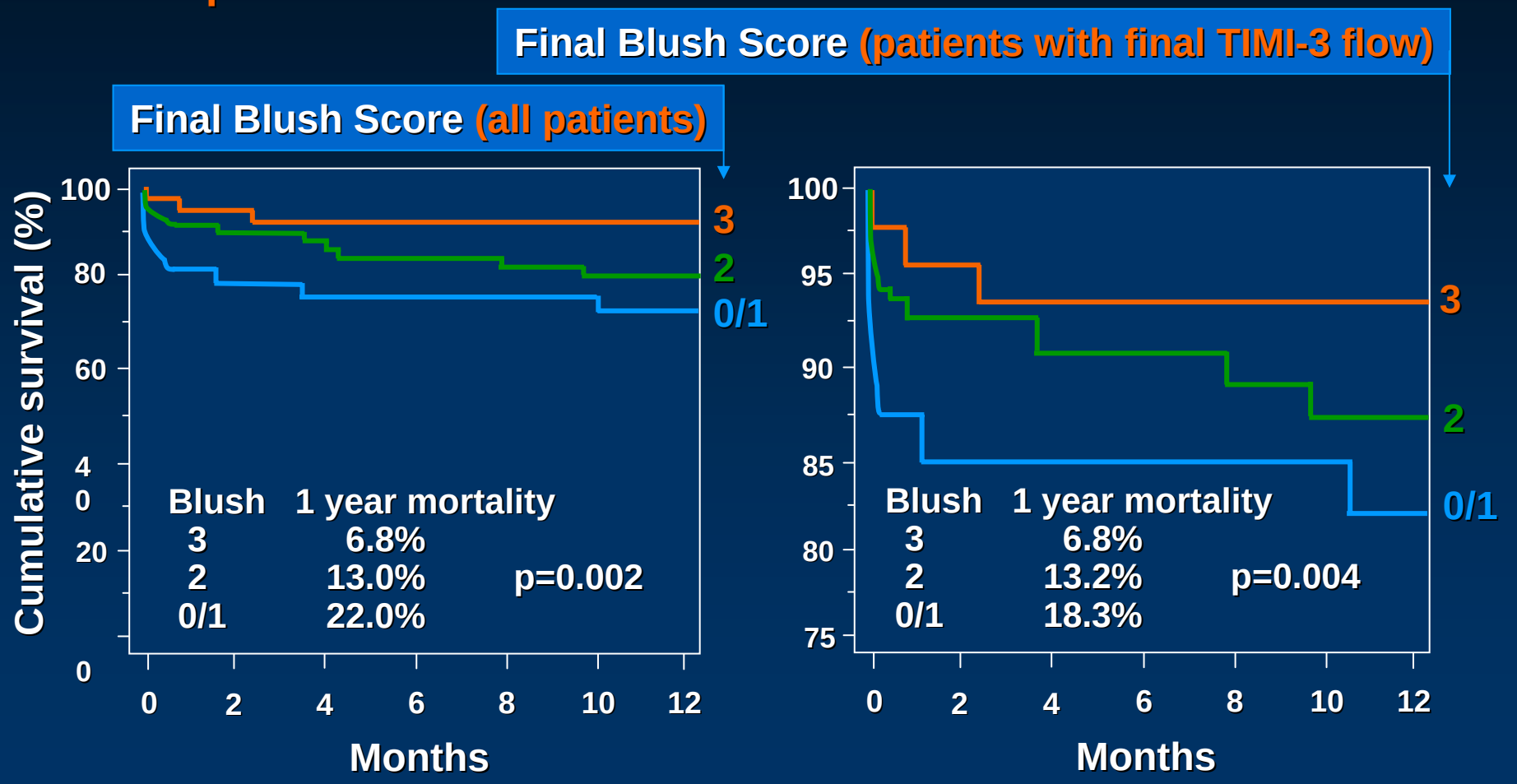
Invasive Assessment of Microvascular Integrity Indexes in AMI Following Primary PCI

Myeong-Ho Yoon
Ajou University, School of Medicine,
Suwon, Korea

Myocardial Blush Scores

- Cumulative survival (1 yr) after PCI in 173 pts with AMI and in 163 patients in whom TIMI-3 flow was achieved.



Stone GW, et.al. *J Am Coll Cardiol* 2002;39:591

Myocardial Blush Scores

- Inter- and intraobserver variability of myocardial blush grades

			Differences		
	N	Agreement	1 Grade	2 Grades	3 Grades
Intraobserver variability	40	92.5%	7.5%	0%	0%
Interobserver variability	40	85.0%	12.5%	2.5%	0%

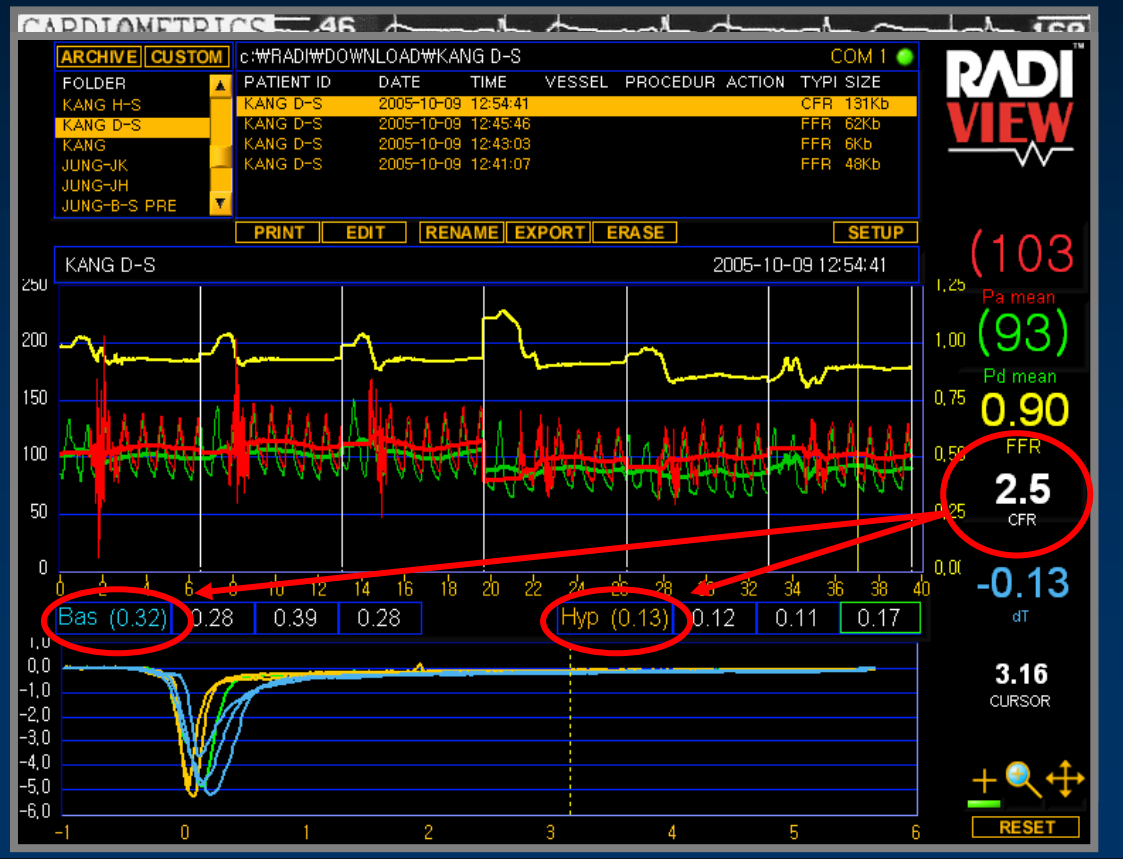
Stone GW, et.al. *J Am Coll Cardiol* 2002;39:591

Coronary Flow Reserve(CFR)

- **CFR is defined as the ratio of maximal coronary blood flow at hyperemia and coronary blood flow at resting which means the reservoir capacity of microvascular circulation according to demand.**

- **CFR doppler**
  = hAPV X CSA / bAPV x CSA
  = hAPV / bAPV

- **CFR thermo**
  = mean bTMN / mean hTMN

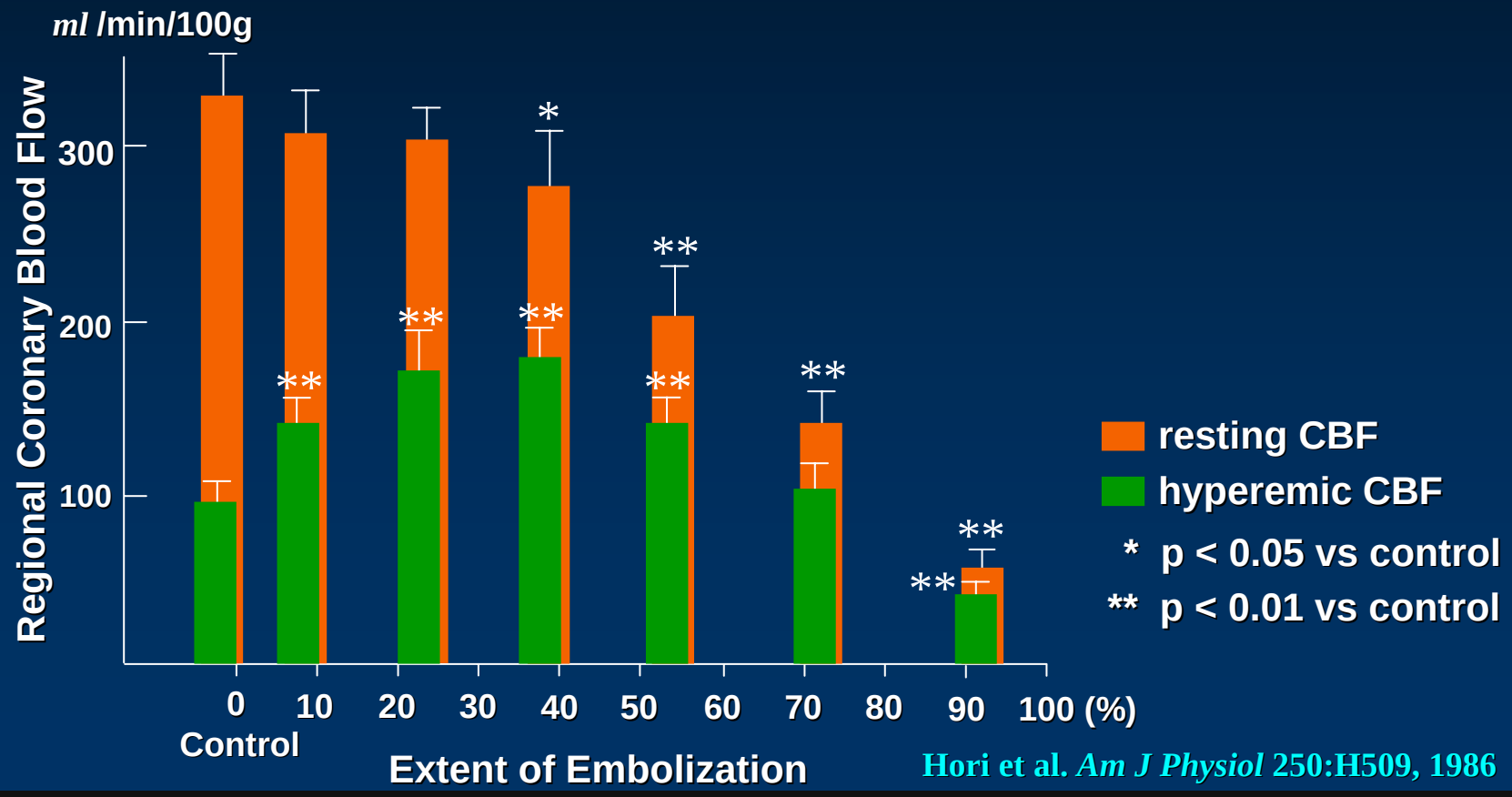


Invasive Measurement of CFR in MI

	Pts no.	PCI time	Measuring CFR	Infarct location	Comparison	F/U
Lepper W. (Circulation 2000;101:2368)	25	Within 6 hours	Just after PCI and after 24 hours	LAD : 11 RCA : 14	MCE	1 month echo
Mazur W. (Am H J 1998;136:335)	29	6.9±3.4 D	Just after PCI	LAD : 15 LCX : 4 RCA : 10	Ventriculograms (LV RWMAs)	6-8 weeks echo
Teiger E. (Eur H J 1999;20:285)	22	16 ±4 D	Just after PCI	LAD : 10 RCA : 12	Thallium 201 SPECT	4 months ventriculogram
Beygui F. (J Am Coll Cardiol 2002;40:877)	41	Within 6 hours	Pre-discharge	LAD : 16 RCA : 25	Thallium 201 SPECT	6 months Thallium 201 SPECT
Feldman LJ (Circulation 2003;107:2684)	50	Within 12 hours	Just after PCI	LAD : 32	ST resolution Thallium 201 SPECT	
Shimada Y. (Circ J 2004;68:208)	37	Within 12 hours	3 weeks after PCI (pre-discharge)	LAD : 37	Ventriculograms (LVEDV)	3 wks, 6 months ventriculogram
Sezer M (Heart 2006;29)	41	Primary	Within 48 hours after PCI	LAD : 41	Hematologic indexes	.

Physiologic Impact of Distal Embolization

- Open chest dogs embolized with microspheres 15, 100, 300 micron, up to 10^5/g of myocardium.
- Initial increase in resting flow (adenosine) but with blunting of hyperemia, and then reduction in resting flow as particulate burden increased.



Hori et al. *Am J Physiol* 250:H509, 1986

CFR and LV Function Changes

	Reperfusion Group (n=13)	Nonreperfusion Group (n=12)	p
CFR after PCI	1.67±0.47	1.48±0.31	0.289
CFR at 24 hr follow-up	2.15±0.53	1.58±0.30	0.003

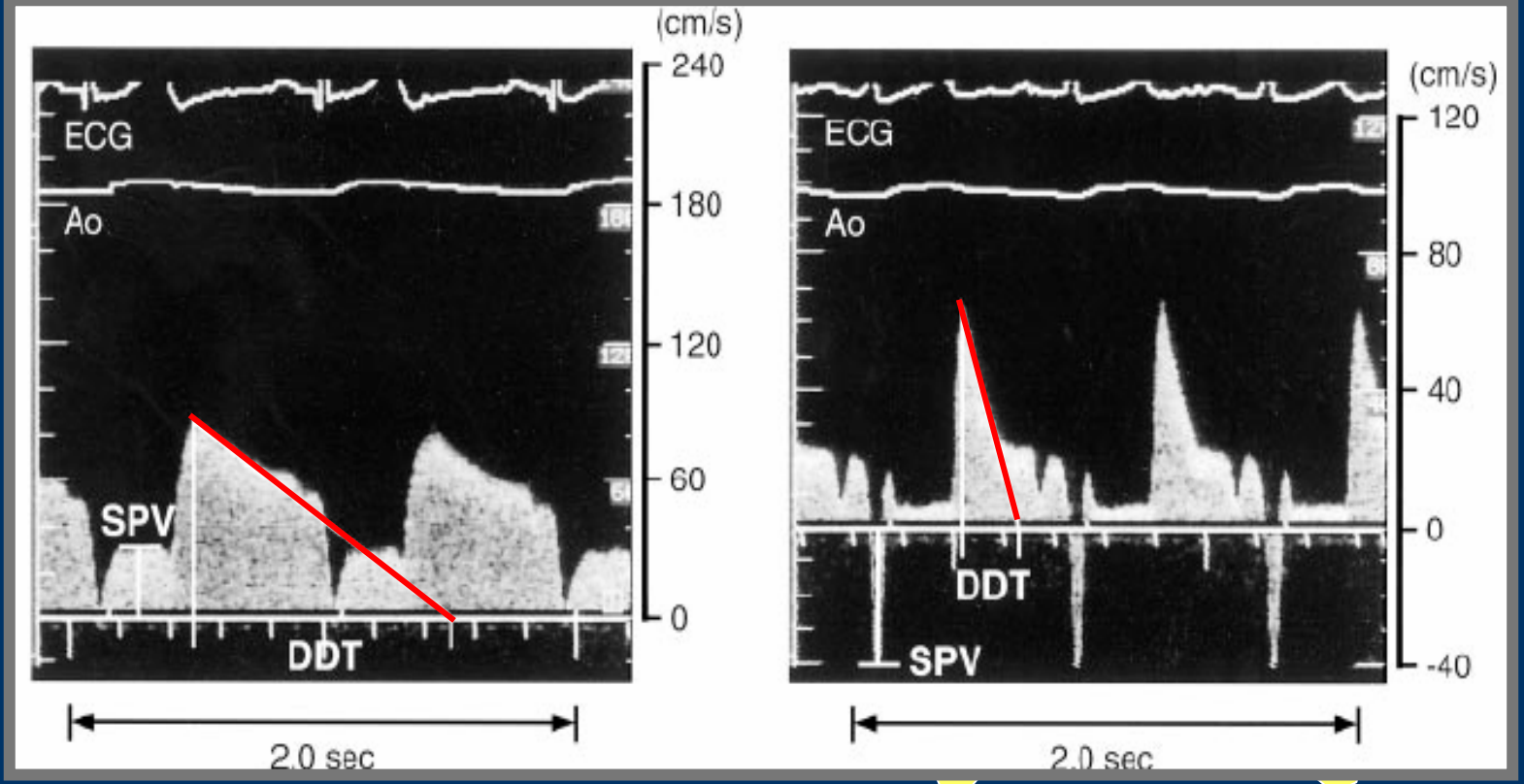
	Recovery Group (n=17)	Nonrecovery Group (n=8)	p
CFR after PCI	1.64±0.42	1.51±0.40	0.451
CFR at 24 hr follow-up	2.15±0.47	1.37±0.11	<0.001

Lepper W, et al. *Circulation* 2000;101:2368

Microvascular Integrity and Coronary Blood Flow Patterns

Mild myocardial damage

Severe myocardial damage



Iwakura. et al. *Circulation* 1996;94:1269-75

Microvascular Integrity and Coronary Blood Flow Patterns

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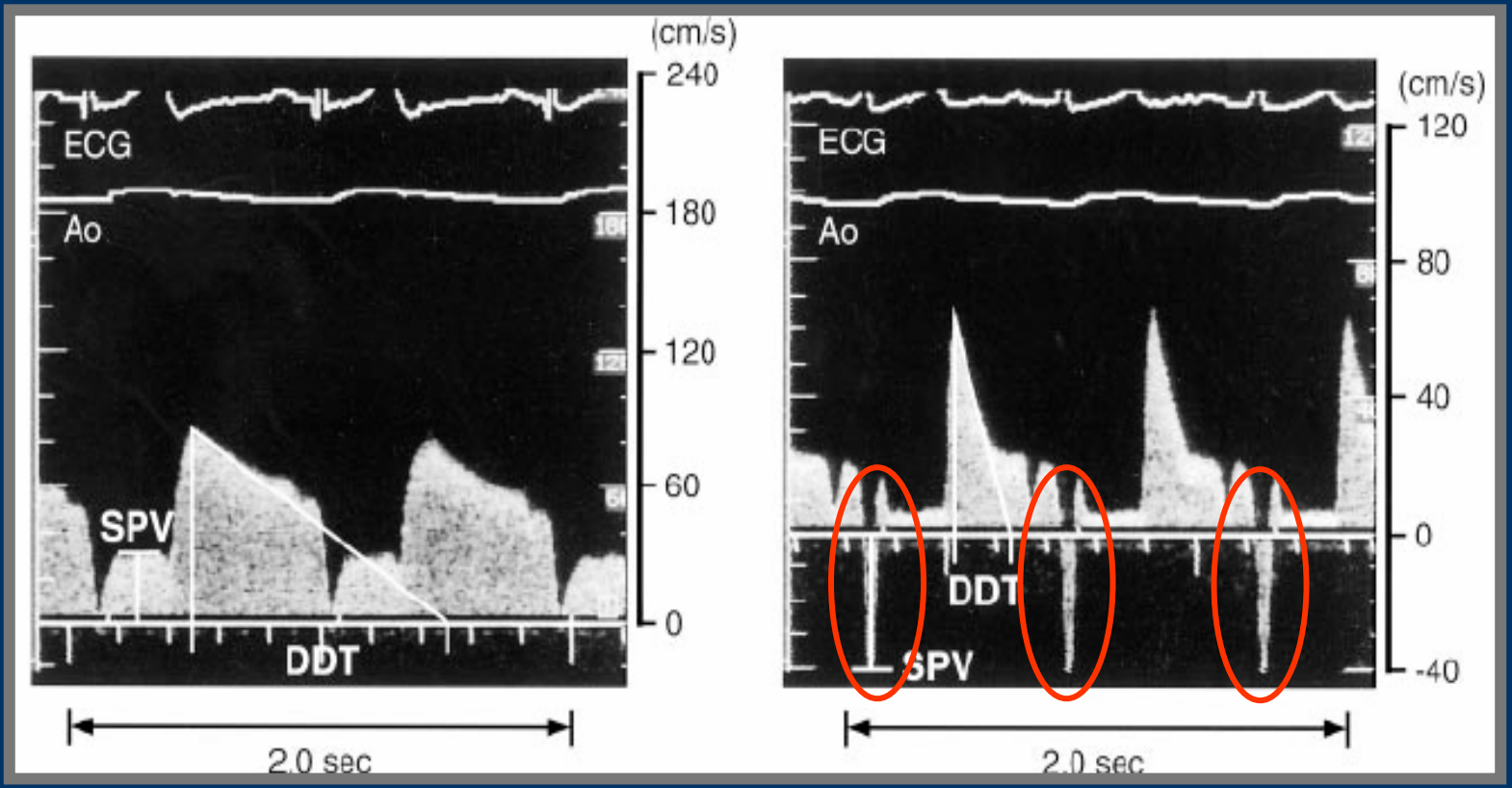
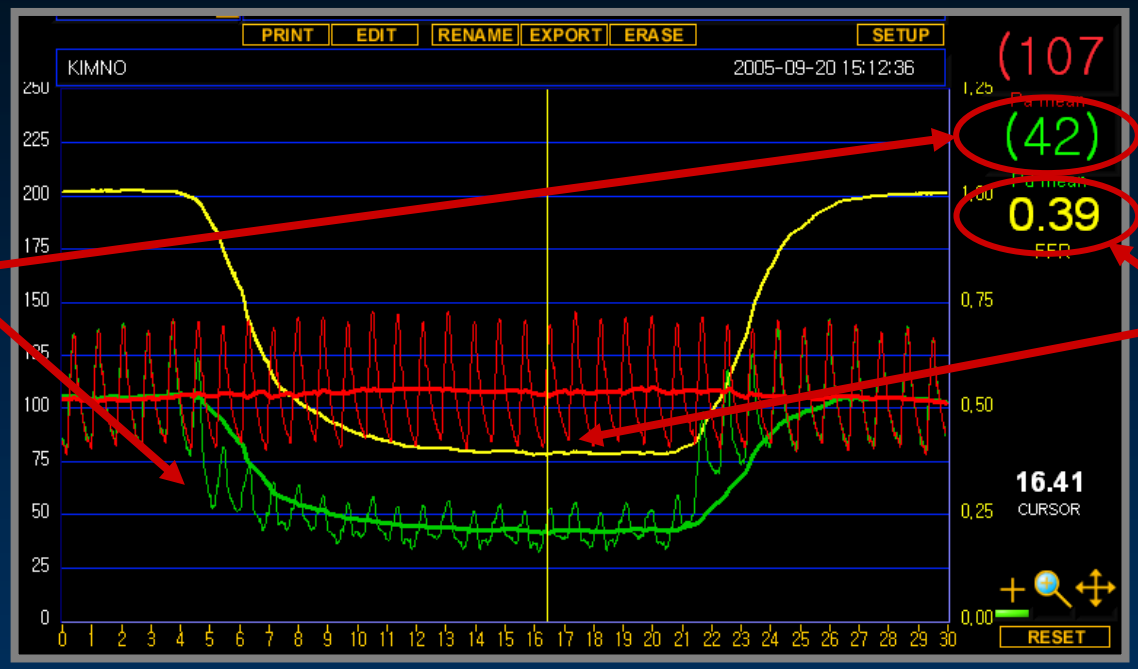


Iwakura. et al. *Circulation* 1996;94:1269-75

Coronary Flow Velocity Patterns

	Pts no.	Reperfusion time	Measuring flow patterns	Infarct location	Comparison	F/U
Yamamoto K. (J Am Coll Cardiol 2002;40:877)	105	About 9 hours	Just after PCI	LAD : 57 LCX : 9 RCA : 39	MCE TIMI grade	.
Iwakura K. (*Circulation.* 1996;94:1269)	42	?	Just after PCI	LAD : 28 LCX : 4 RCA : 10	MCE	.
Akasaka T (Circulation 1999;100:339)	23	Within 12 hours	Just after PCI	LAD : 23	RWMAs by Echo	1 month Echo
Lepper W (J Am Coll Cardiol 2002;39:1283)	25	Within 6 hours	Just after PCI		MCE	1 month MCE
Okamura A (Am J Cardiol 2005;96:927)	72	Within 24 hours	Just after PCI	LAD : 72	Cardiac enzyme TIMI flow	.
Hoffmann R (Heart 2003;89:1147)	35	Within 6 hours	Just after PCI	LAD: 15 RCA: 20	TMPG	.
Furber AP (Circulation 2004;110:3527)	68	7.6 ± 7.0 h	Just after PCI	LAD : 36 LCX : 6 RCA : 30		MACE 3.8 yrs

Coronary Wedge Pressure

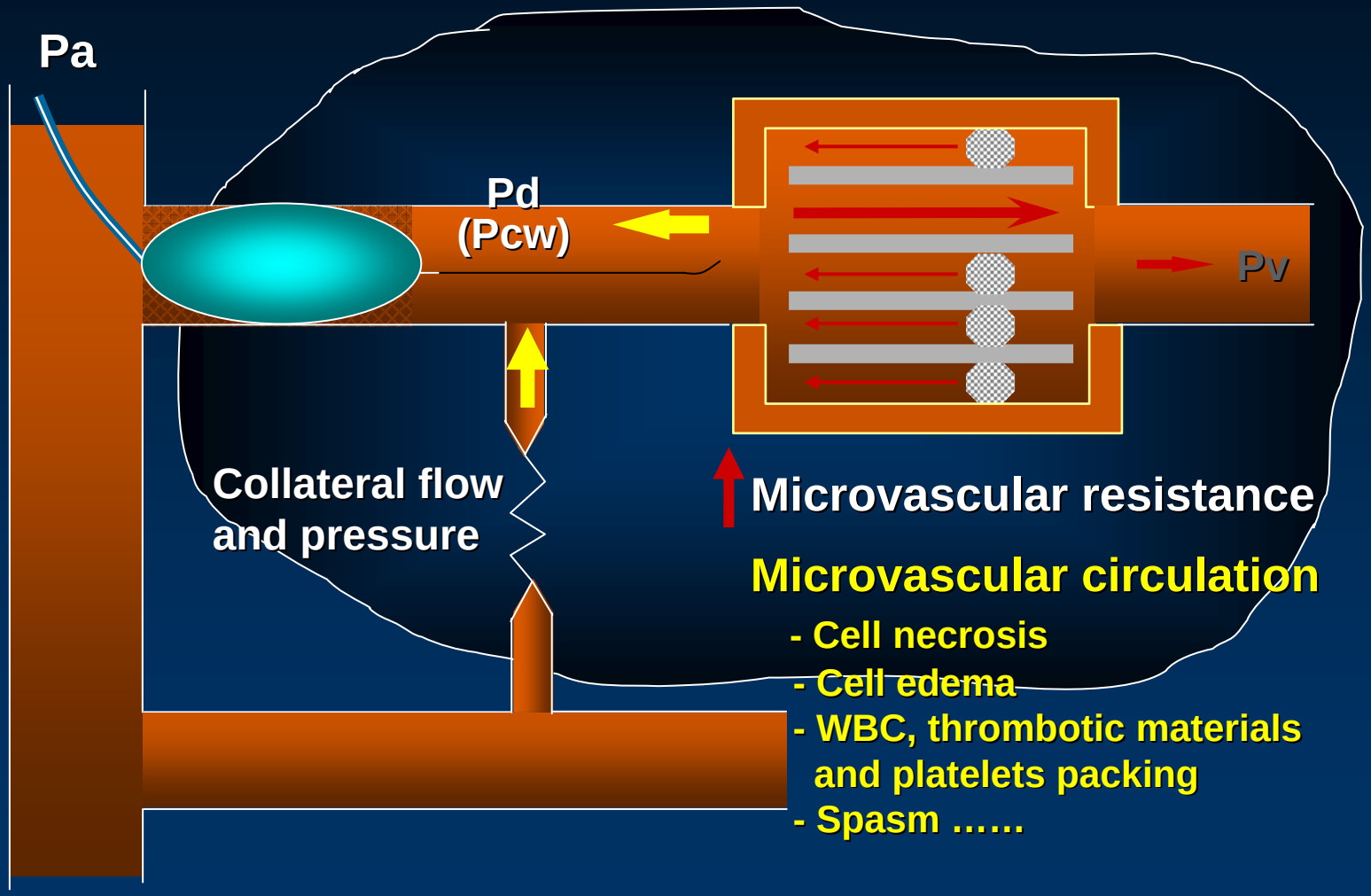


Pcw

Pcw / Pa

- **Coronary Wedge Pressure (Pcw)**
  - The distal coronary artery wedge pressure during balloon occlusion
- **Pressure derived Collateral Flow Index (CFIp)**
  - (Pcw – Pv) / (Pa – Pv)
  - simplified by Pcw / Pa

Coronary Wedge Pressure and Collateral Flow in AMI

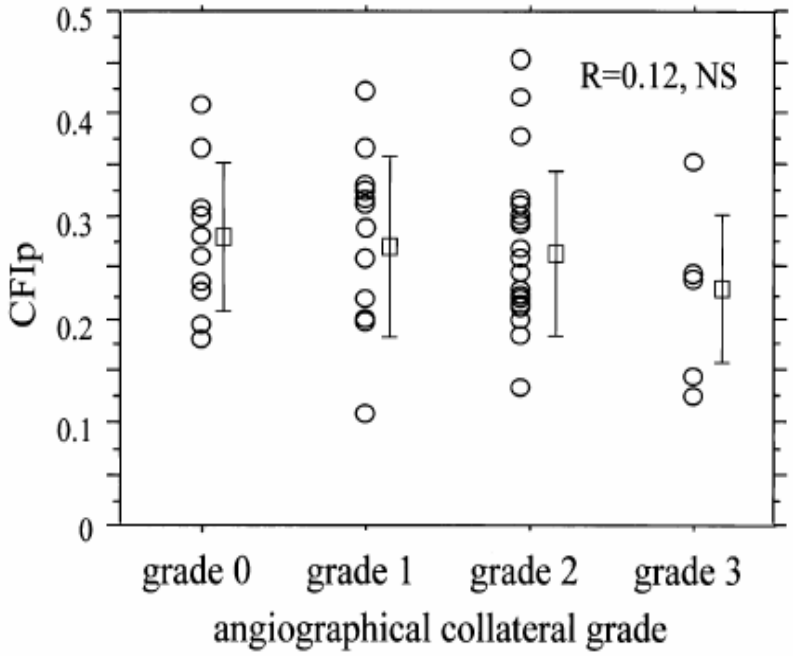


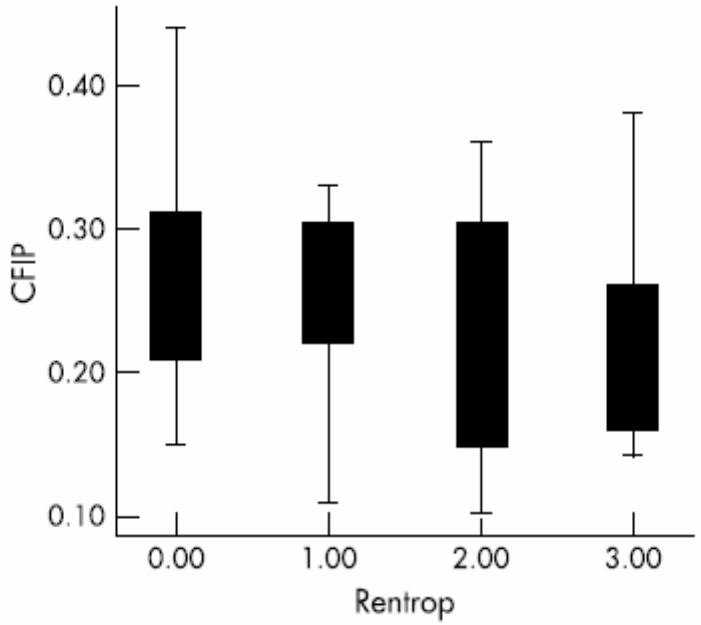
Microvascular circulation

- Cell necrosis
- Cell edema
- WBC, thrombotic materials and platelets packing
- Spasm ……

Coronary Wedge Pressure

- Comparison of pressure-derived collateral flow index(CFIp) among angiographically collateral grades in AMI with PCI within 12 hours.

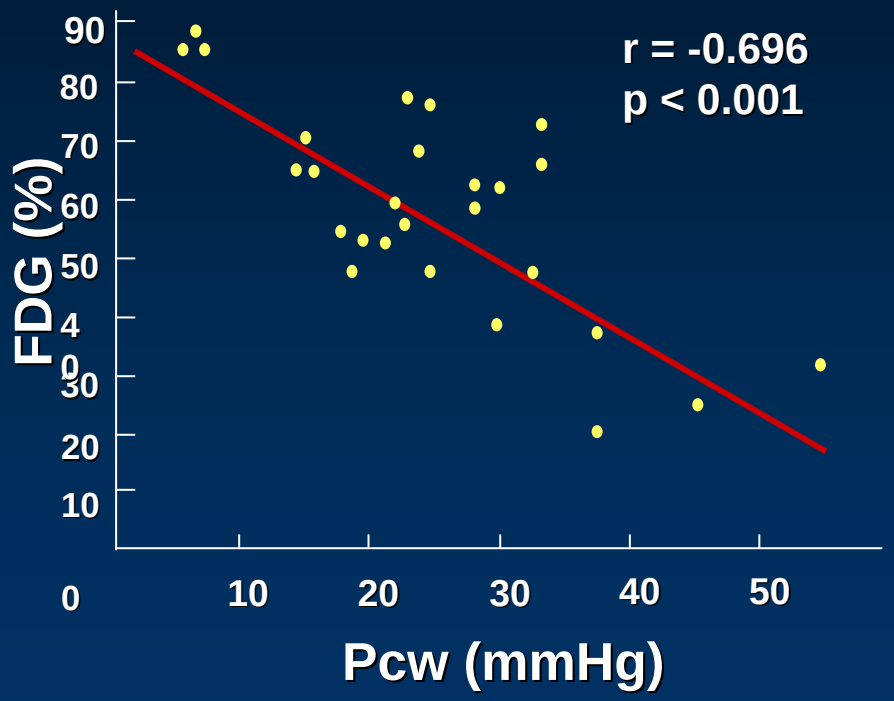


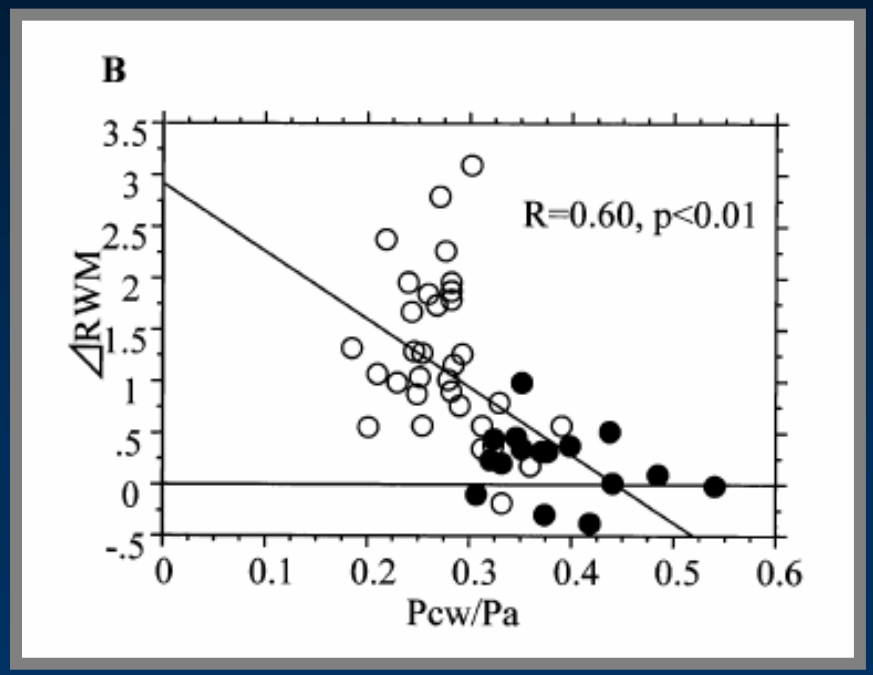


Yamamoto, et al. *J Am Coll Cardiol* 2001;38:1383
Sezer M, et al. *Heart* 2004;90:146

Coronary Wedge Pressure

- Relationship between Pcw and % FDG uptake, wall moton chandes



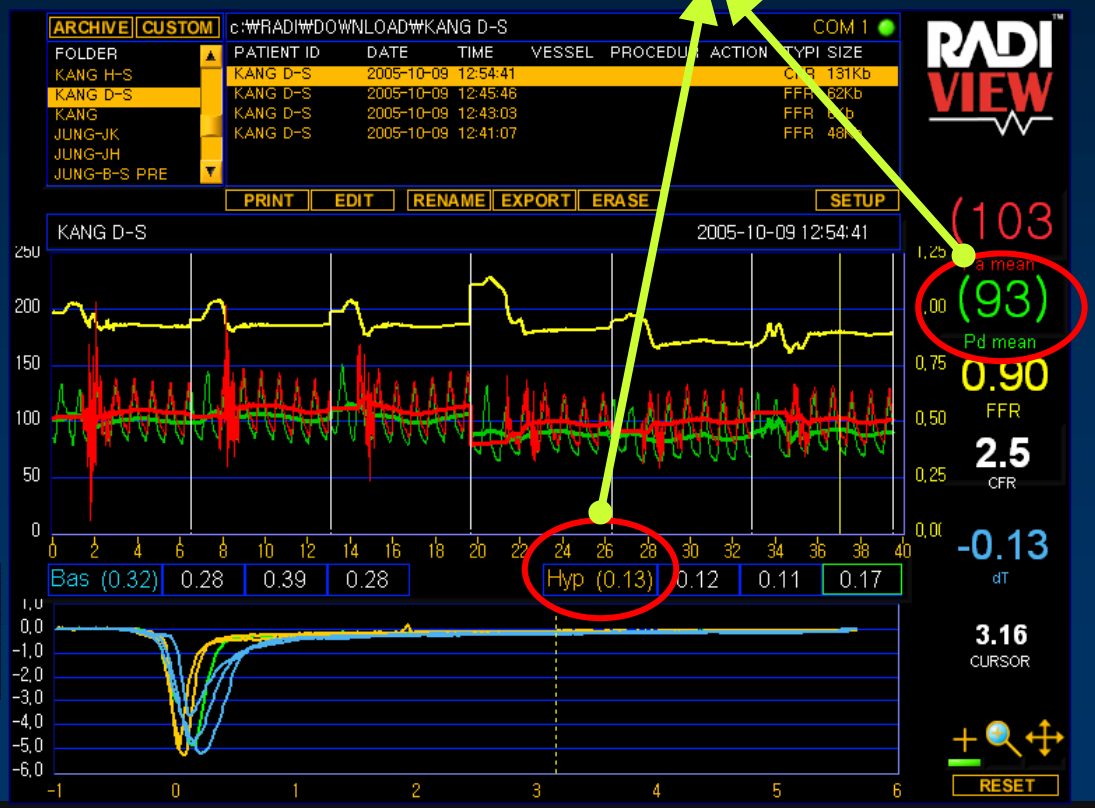


Yamamoto, et al. *J Am Coll Cardiol* 2001;38:1383
Shimada, et al. *Heart* 2003;38:71-6

Index of Microvascular Resistance (IMR)

- **Derivation of Index of Microcirculatory Resistance (IMR)**
- **Resistance = Δ Pressure / Flow**
- **IMR = $(P_d - P_v) / (1 / T_{mn})$**
- **IMR = $P_d \times T_{mn}$**
  at maximal hyperemia

IMR : 12.1 U



Pd: coronary distal Pressure

Tmn: mean transit time

IMR and Microvascular Damages

- Twenty-seven patients with STEMI treated with primary stenting.

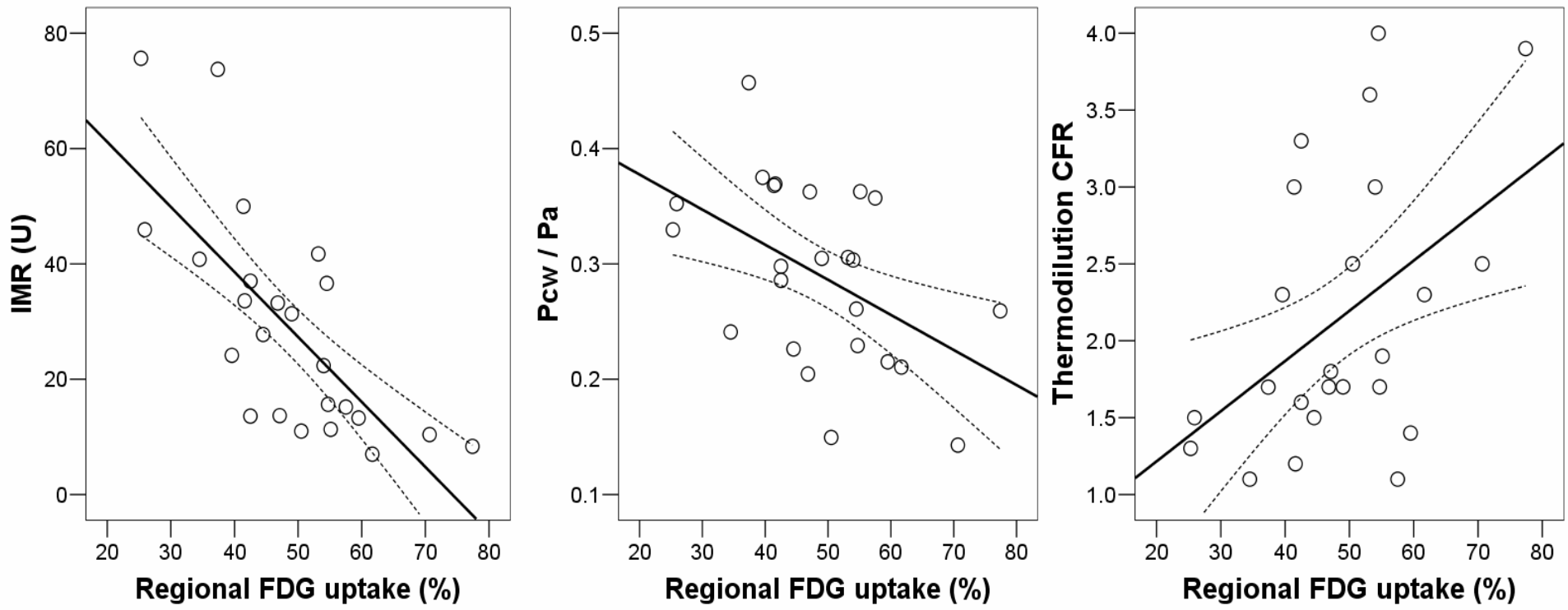
	IMR	
	r	p
Peak CK	0.54	0.004
Neutrophil %	0.52	0.01
TMPG	-0.42	0.03
TFG	-0.44	0.03
CFR	-0.43	0.03
cTFC	0.54	0.004

- IMR above the median level of 35 had greater peak CK (3387±1531 vs. 1209±966 IU, p=0.03)

Fearon W et al. Abstracts, *Circulation* 2006;II-586

IMR and Cardiac PET

- Correlation between IMR and FDG uptake rate by Cardiac PET
- Twenty-four patients with STEMI treated with primary PCI was studied.

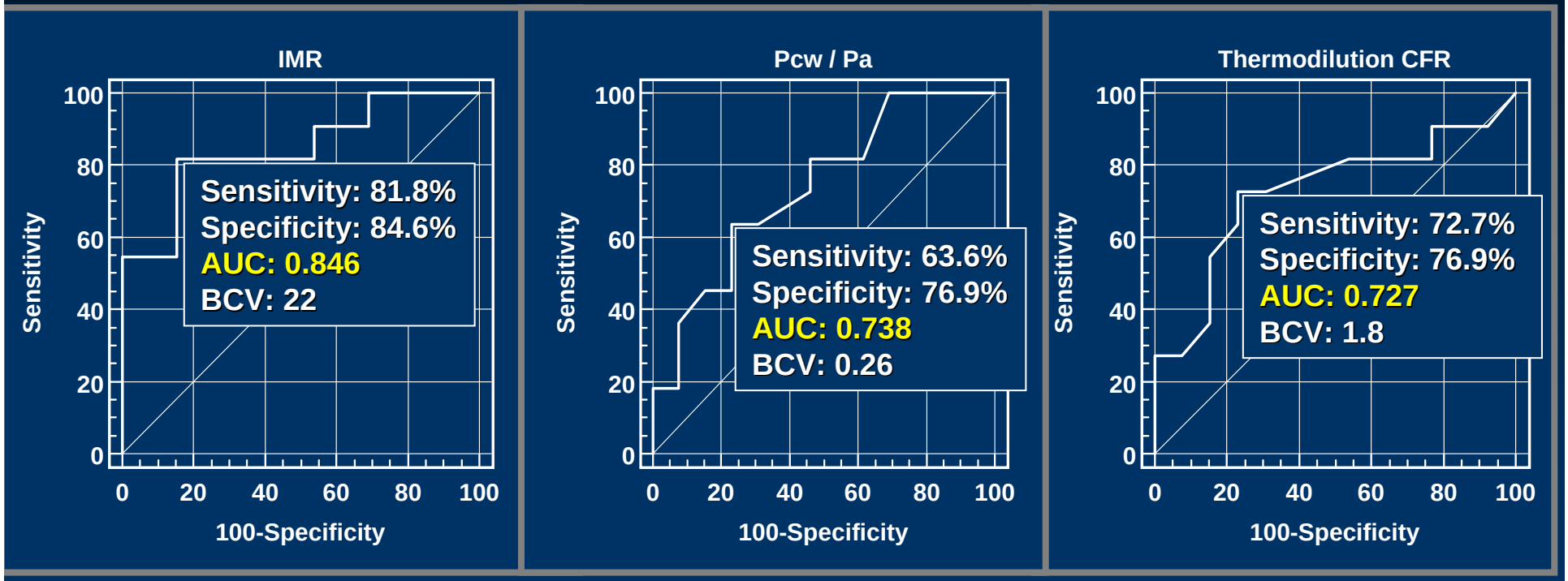


r = -0.696 p < 0.001	r = -0.480 p = 0.018	r = 0.454 p = 0.026

SJ Tahk, HS Lim, et al. *Korean Circulation* 2006;36(suppl II)

IMR and Cardiac PET

- Accuracy of IMR for predicting viability (50%>FDG uptake rate)

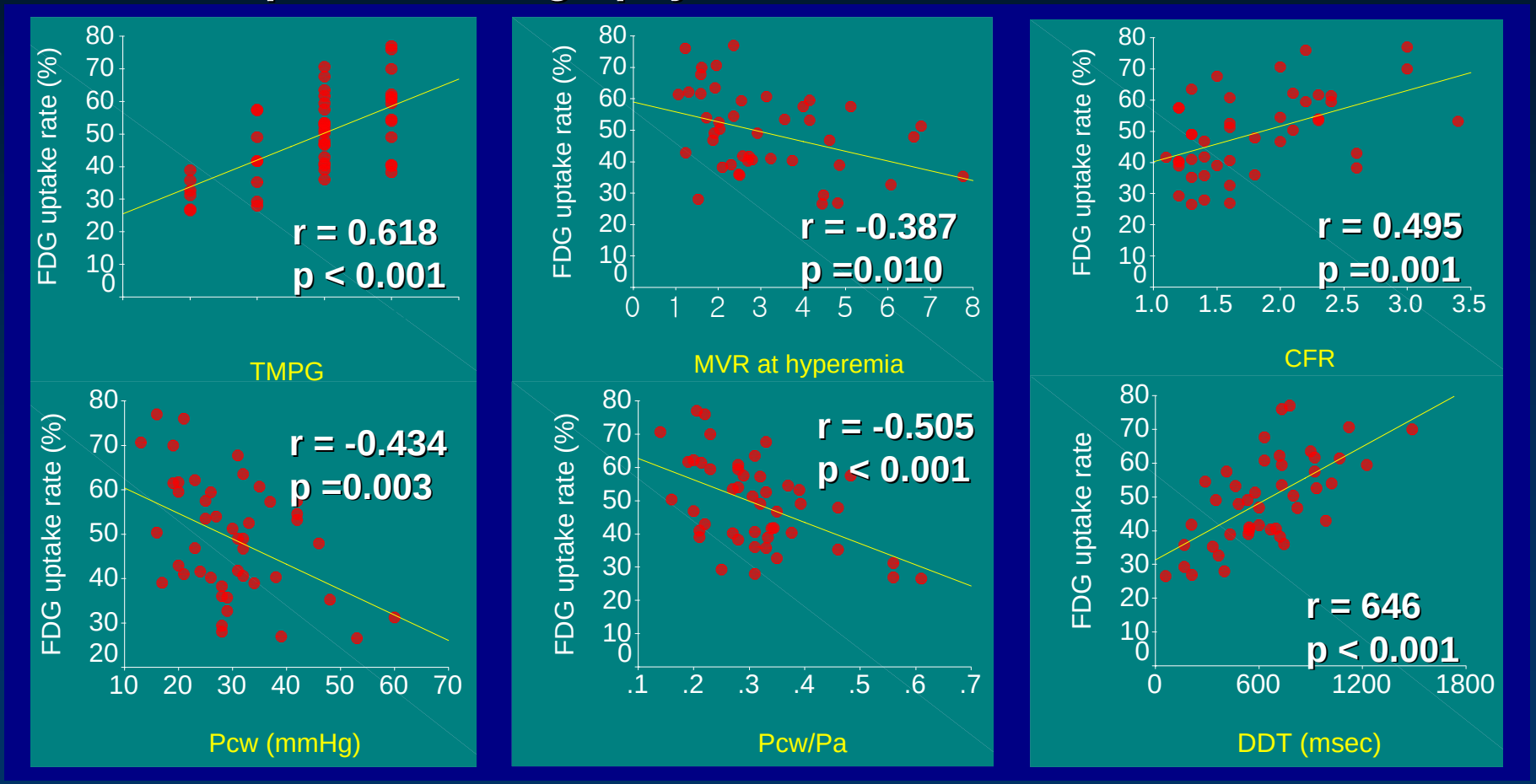


AUC: Area under the Curve
BCV: Best Cutoff Value

SJ Tahk, HS Lim, et al. *Korean Circulation* 2006;36(suppl II)

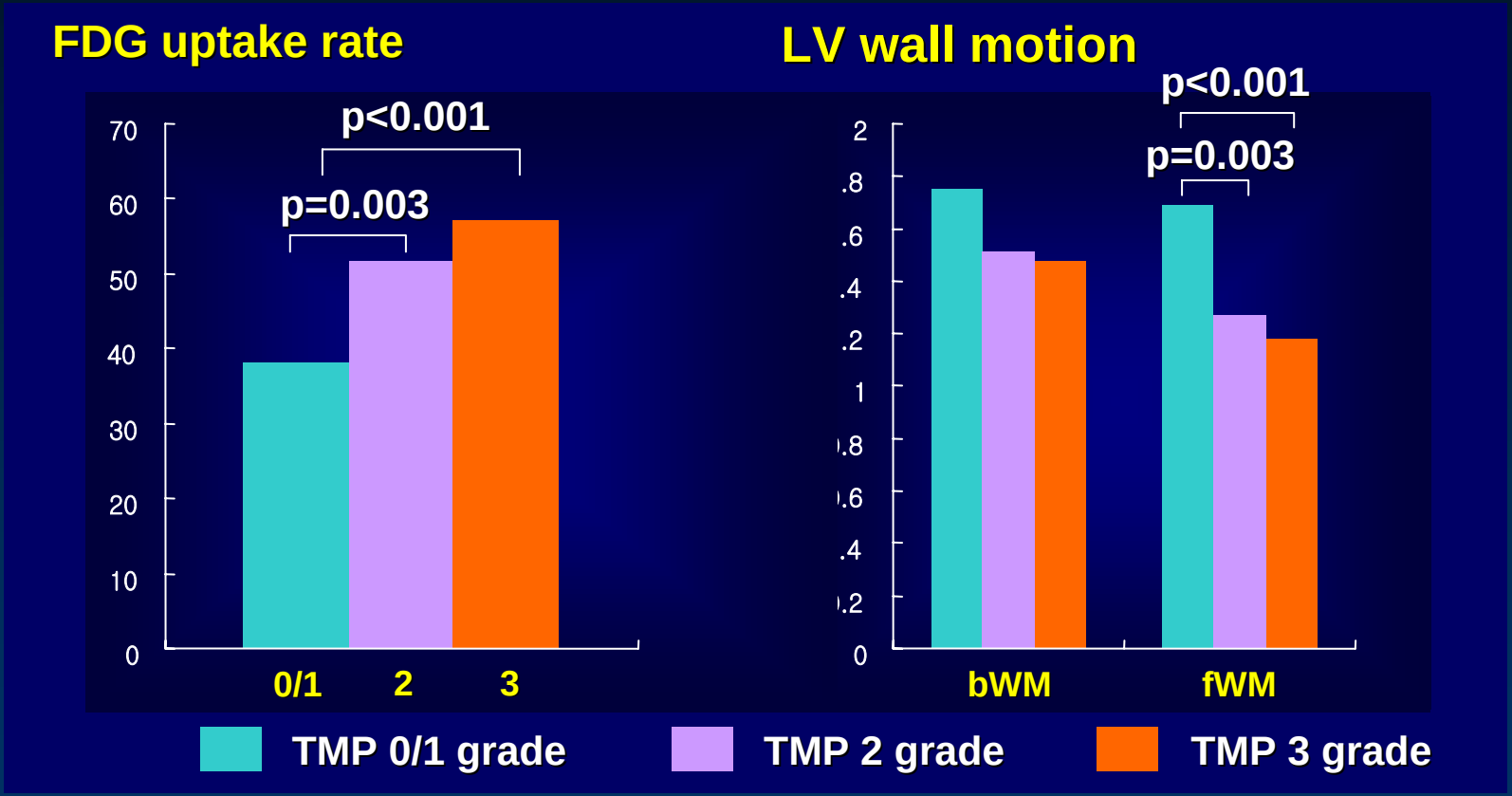
Correlation of Microvascular Integrity Indexes with FDG PET

- **Forty-six patients** with STEMI treated with primary PCI and follow up echocardiography at 6 months was studied.



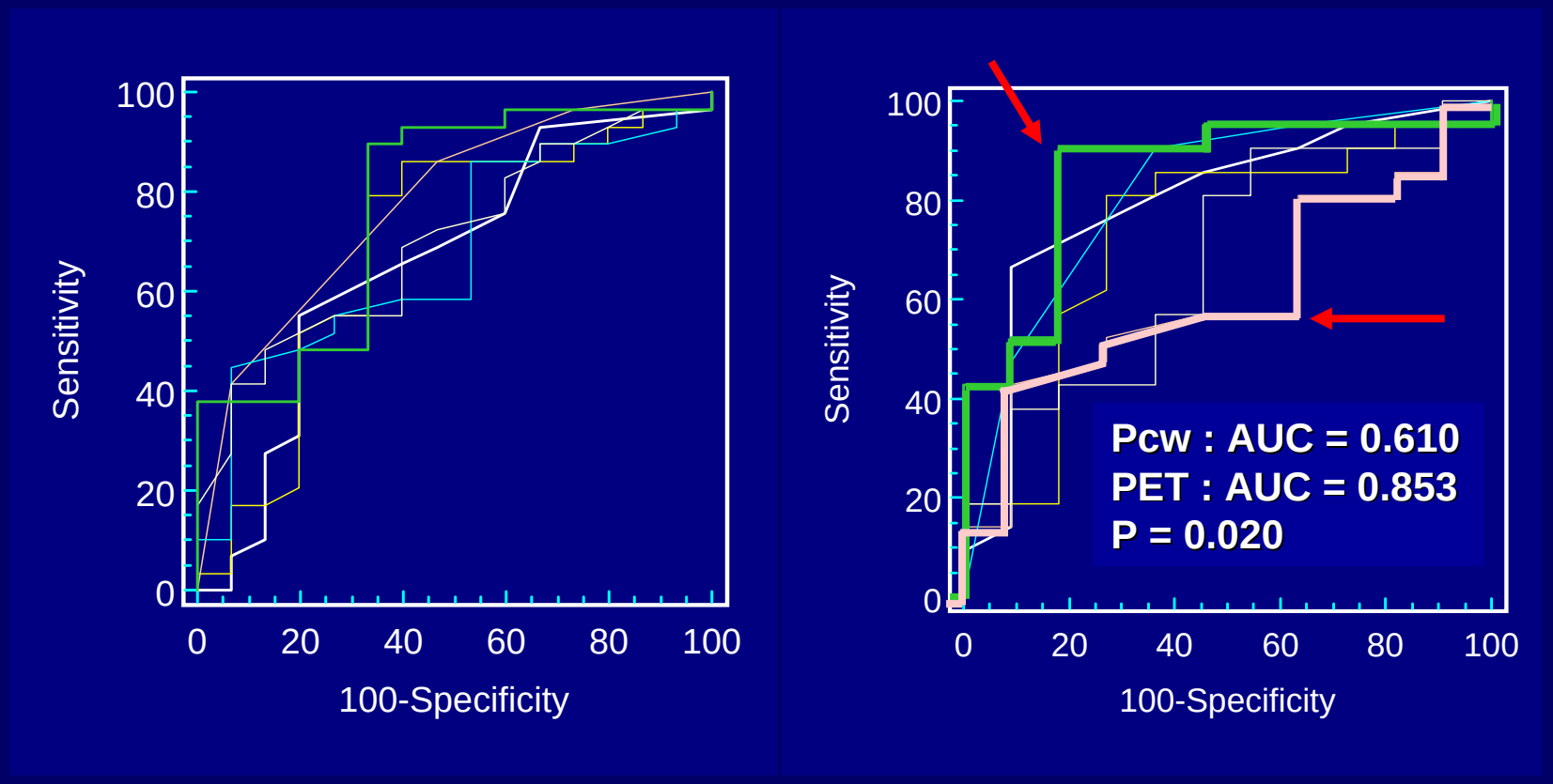
SJ Tahk, MH Yoon, et al. *Korean Circulation* 2006;36:701

Comparison Between TMPG and the FDG Uptake, LV Wall Motion



SJ Tahk, et al. *Circulation* 2006;114:II:II-784

Comparison of the Accuracy Each Indices and PET for Predicting LV Wall Motion



All Patients (n=46) **Ant. Wall MI Patients (n=34)**

CFR
DDT
Pcw
TMPG
MVR
FDG uptake

Limitations

- Although, the TMPG is a subjective index, it might be a simple and useful index for predicting microvascular integrity and LV functional changes.
- Although, there are little studies about the IMR, it might be an excellent index for predicting microvascular integrity in AMI regardless of the patient's hemodynamic status.
- The CFR might be a good index for predicting microvascular integrity, however, it was affected by patient's hemodynamics and baseline flows after primary PCI in acute stage of AMI.
-
- The Pcw might represent the microvascular tone and function, However, further study will be required about the effect of collateral flows on the Pcw in acute stage of AMI.

Conclusion

- **Indexes of microvascular integrity**, such as CFR, Coronary flow patterns (DDT), MVR index, Pcw/Pa, and TMPG, which are measured during primary PCI in AMI, **are useful and comparable with FDG PET for predicting the LV functional changes.**