Value of Index of Microvascular Resistance (IMR) in Microvascular Integrity

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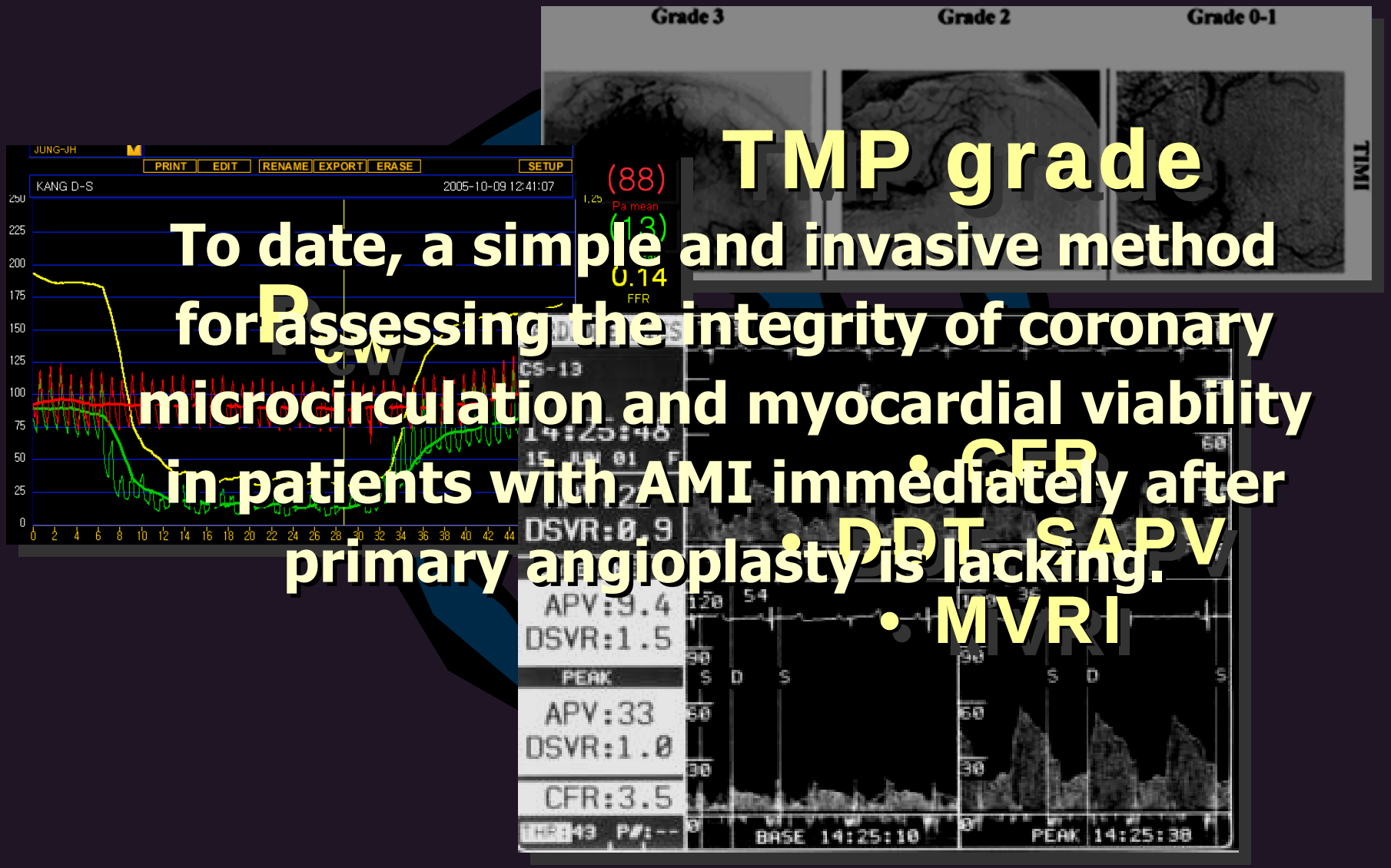
Microvascular Integrity



TMP grade

P_{cw}

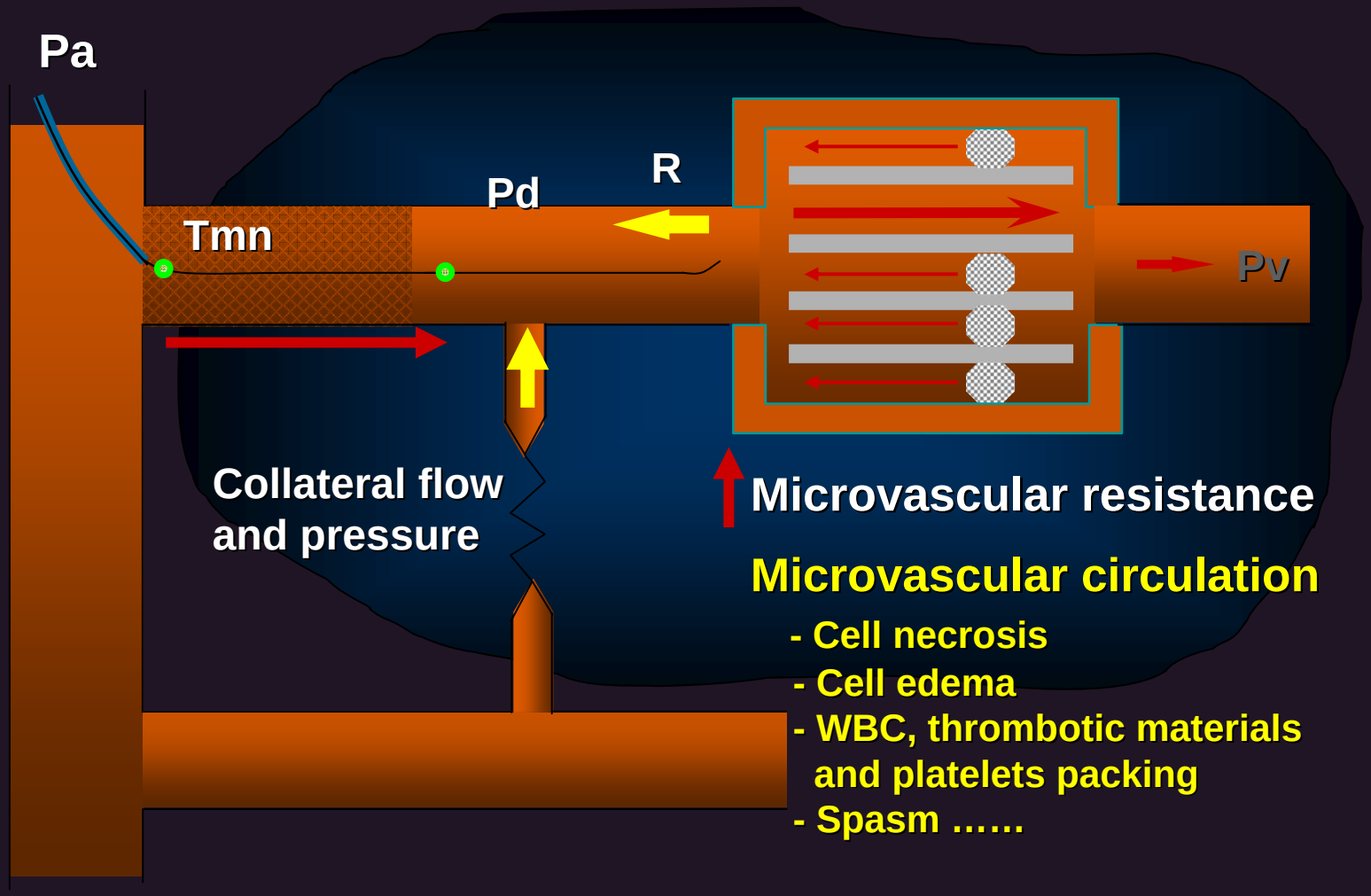
- **CFR**
- **DDT, SAPV**
- **MVRI**

To date, a simple and invasive method for assessing the integrity of coronary microcirculation and myocardial viability in patients with AMI immediately after primary angioplasty is lacking.

Assessment of Microvasculature

1. Noninvasive imaging
   ; Contrast Echo, MRI, RI scan, PET…
2. ECG; ST segment resolution
3. Coronary Angiography
   ;TIMI myocardial perfusion grade
4. Physiologic Studies
   1) Coronary flow reserve,
   2) other Doppler parameters
   3) Index of Microcirculatory Resistance (IMR)

Microvascular Integrity



Microvascular circulation

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

Methods

Measurement of coronary pressure parameters

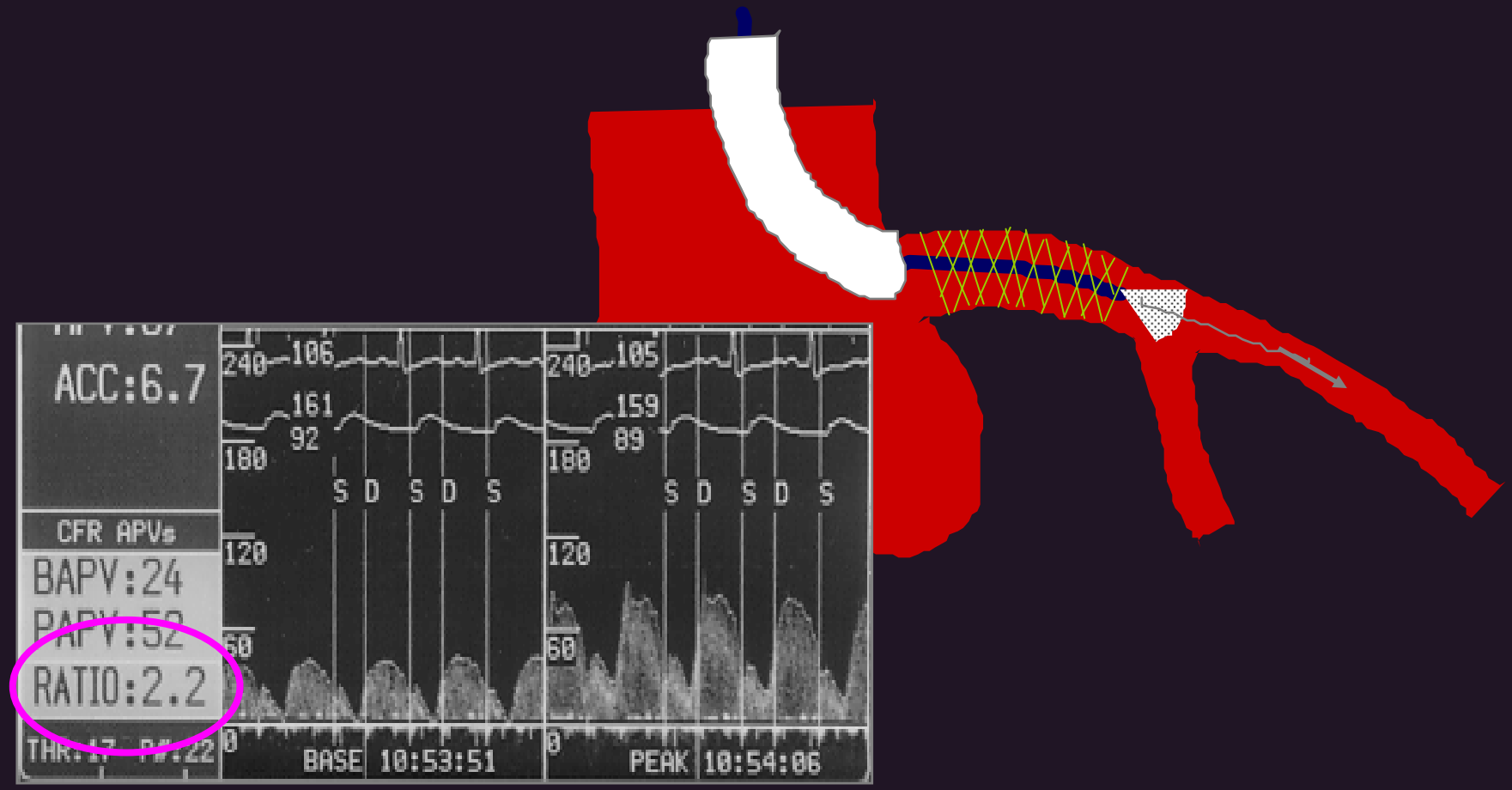
Intracoronary Pressure Wire

(Radi Medical System, Uppsala, Sweden)

- Pa (mean Ao pr.), Pd (mean distal coronary pr.)
- T_{mn} (mean transit time)
- Pcw (coronary wedge pressure), Pcw-Pa ratio (Pcw/Pa)
- Thermodilution CFR = hyperemic T_{mn} / basal T_{mn}
- FFR = hyperemic Pd / hyperemic Pa
- IMR = Pd $\times$ hyperemic T_{mn}

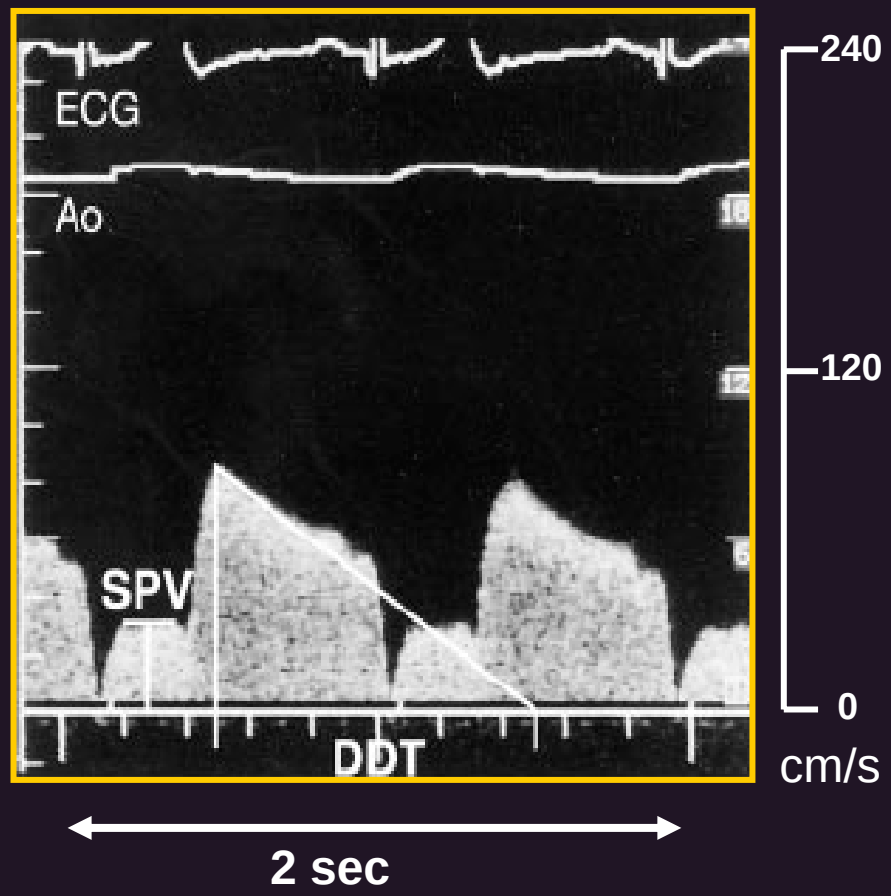
Intracoronary Doppler Measurements

Measurement of CFR

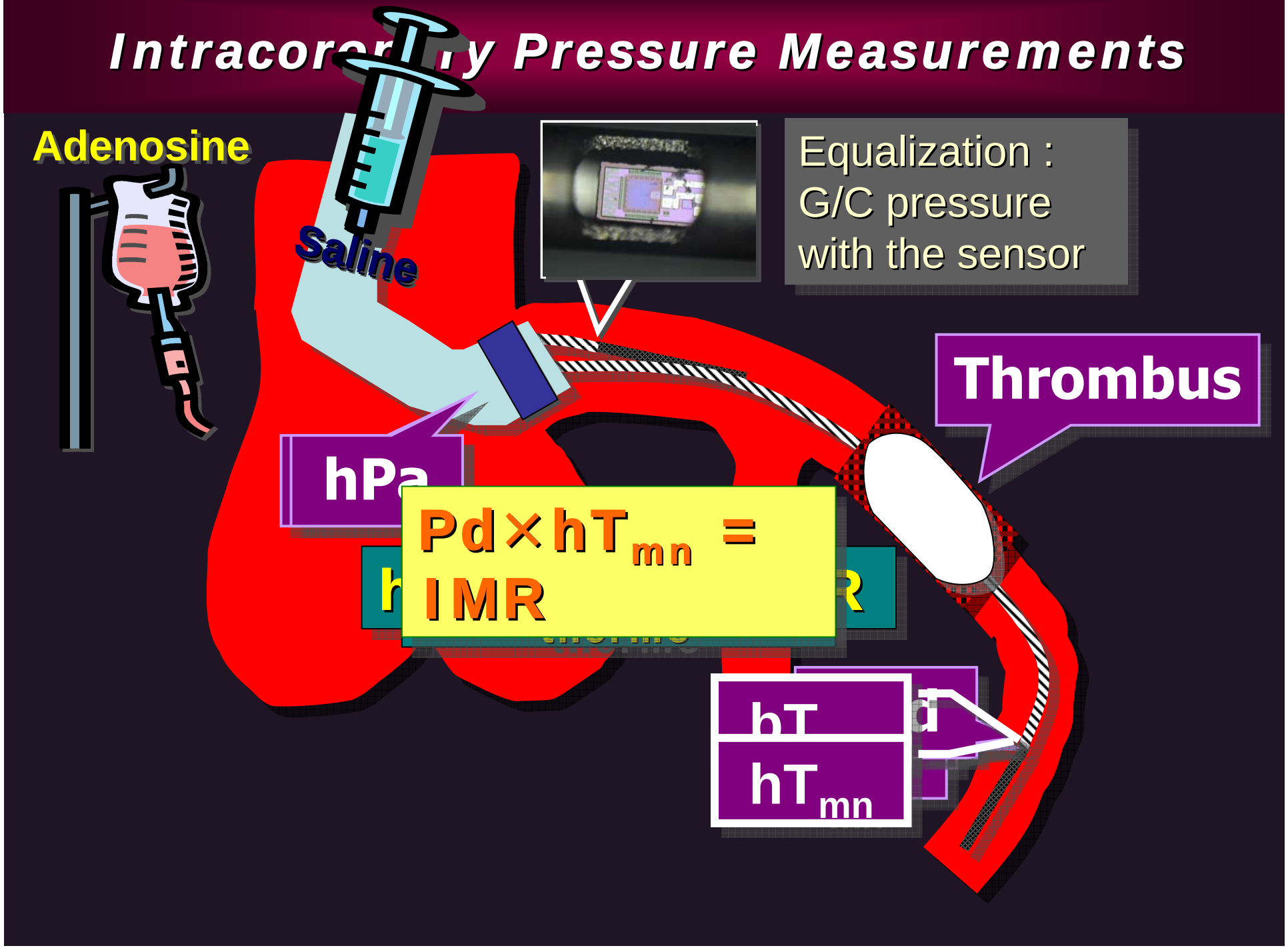


Intracoronary Doppler Measurements

Measurement of DDT



Intracoronary Pressure Measurements



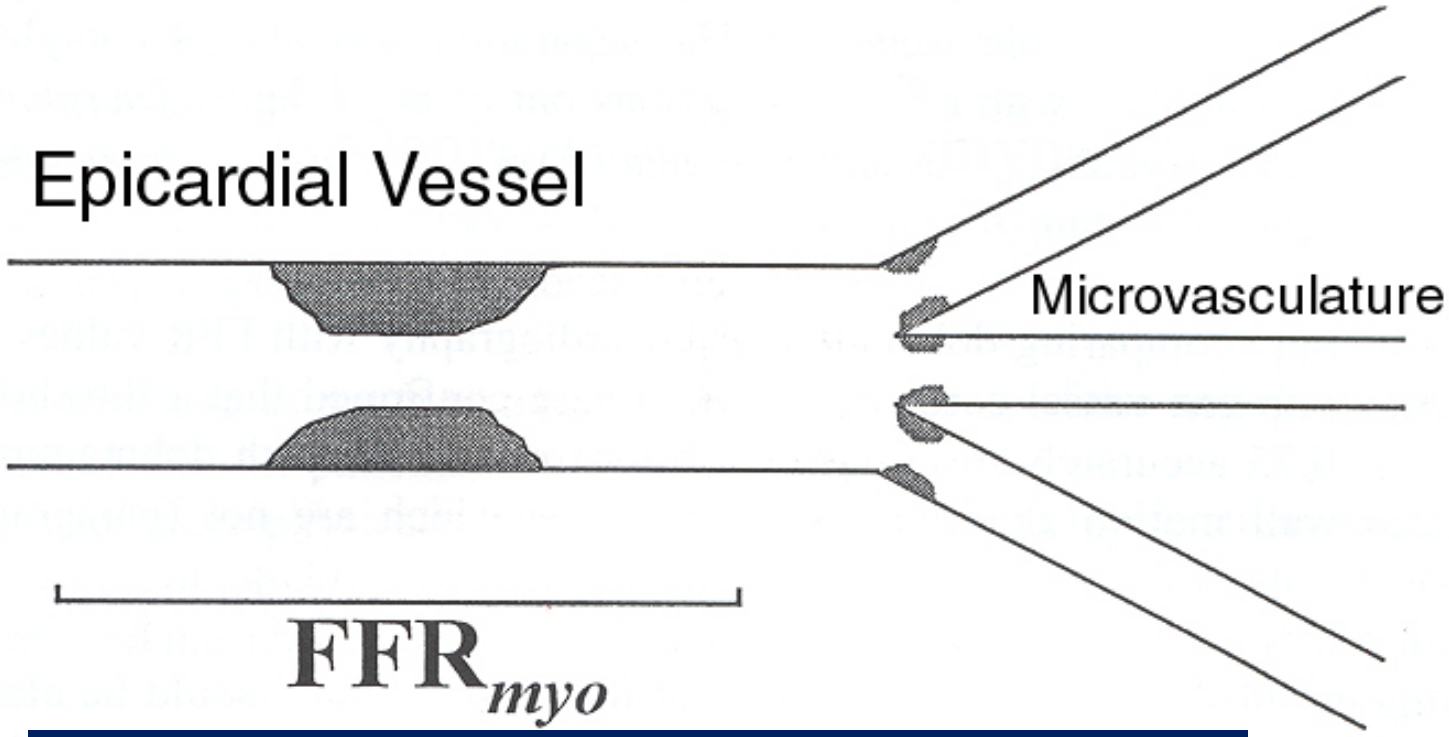
IMR

Derivation of Index of Microcirculatory Resistance (IMR)

* Resistance = Δ Pressure / Flow
* $1 / T_{mn} \cong$ Flow
* $IMR = (P_d - P_v) / (1 / T_{mn})$
* $IMR = P_d \times T_{mn}$

  at maximal hyperemia…

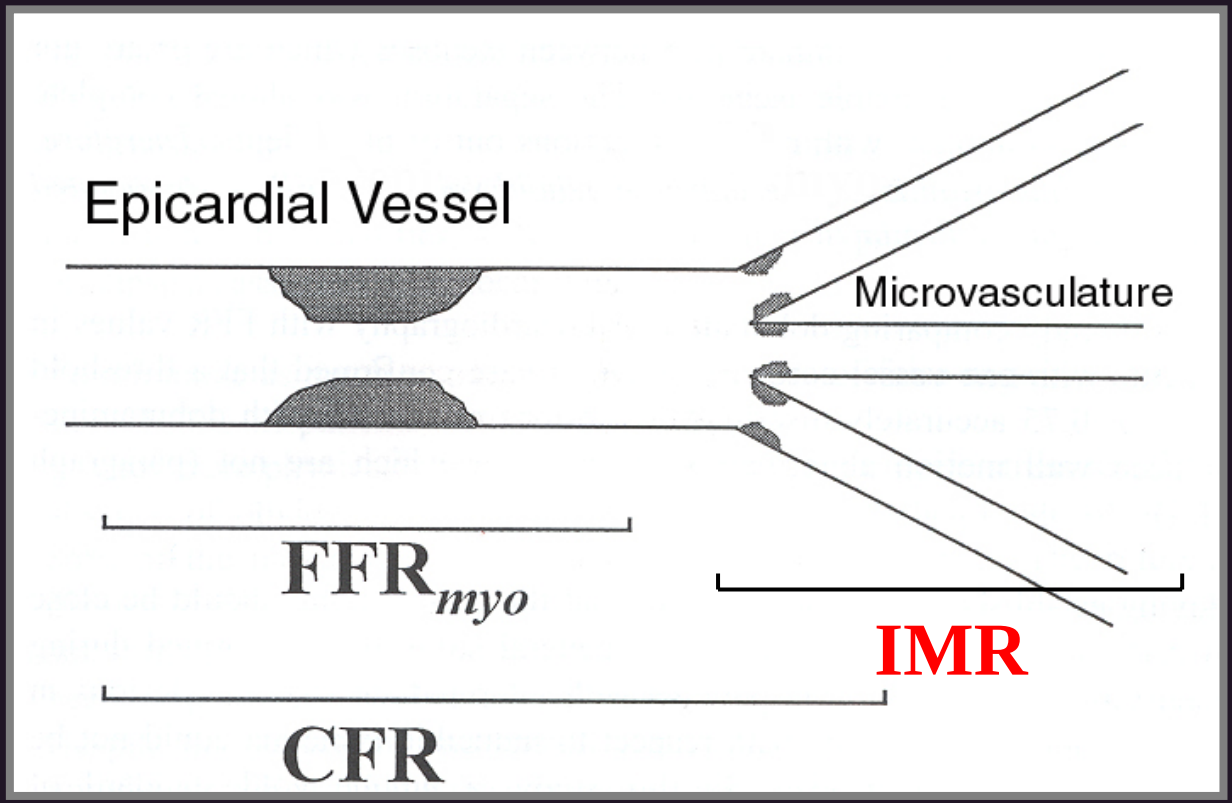
FFR vs. CFR



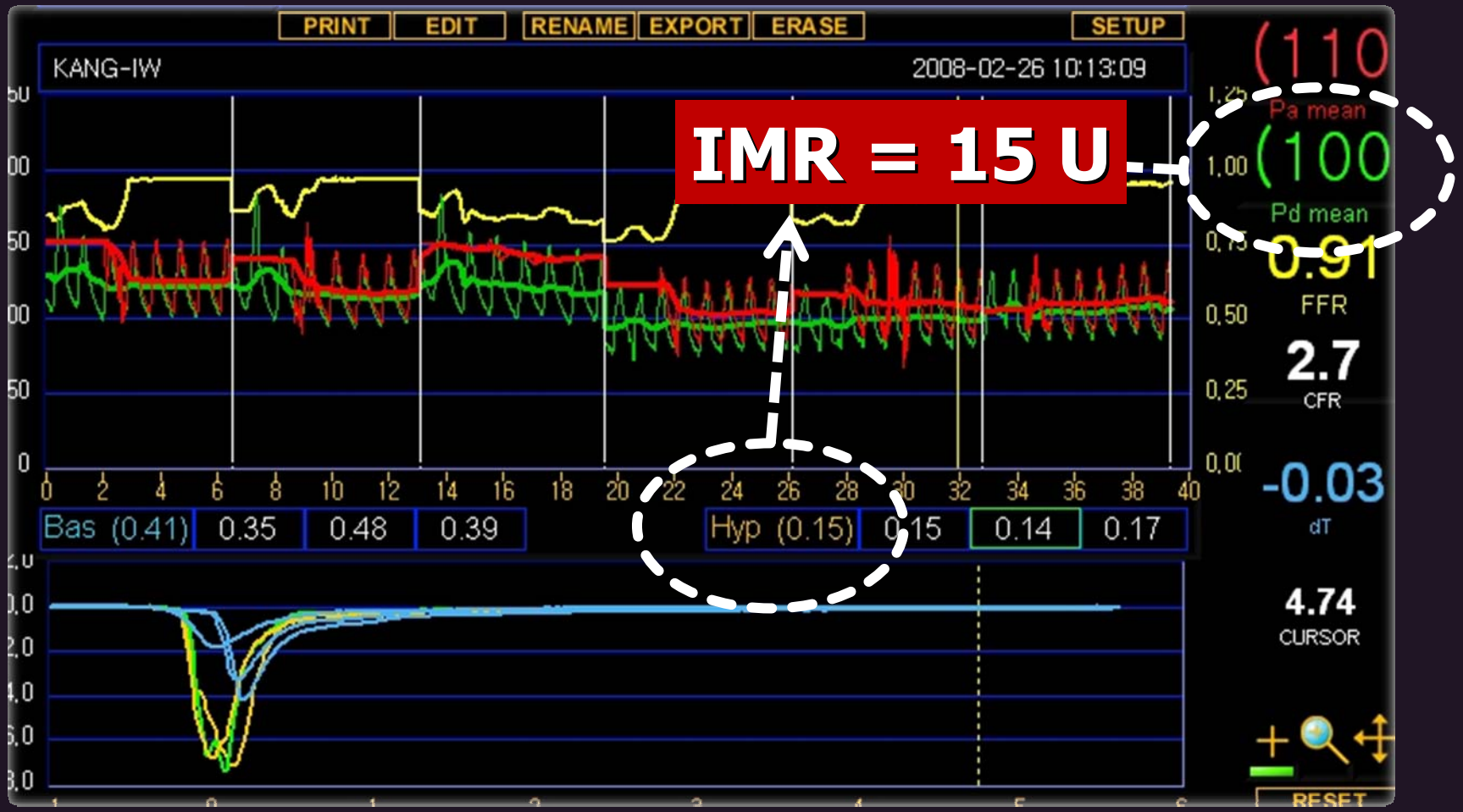
- Clearly defined normal value
- Not affected by resting hemodynamics
- Easy to perform

Adapted from: Pijls and De Bruyne, Coronary Pressure
Kluwer Academic Publishers, 2000

Index of Microcirculatory Resistance (IMR)

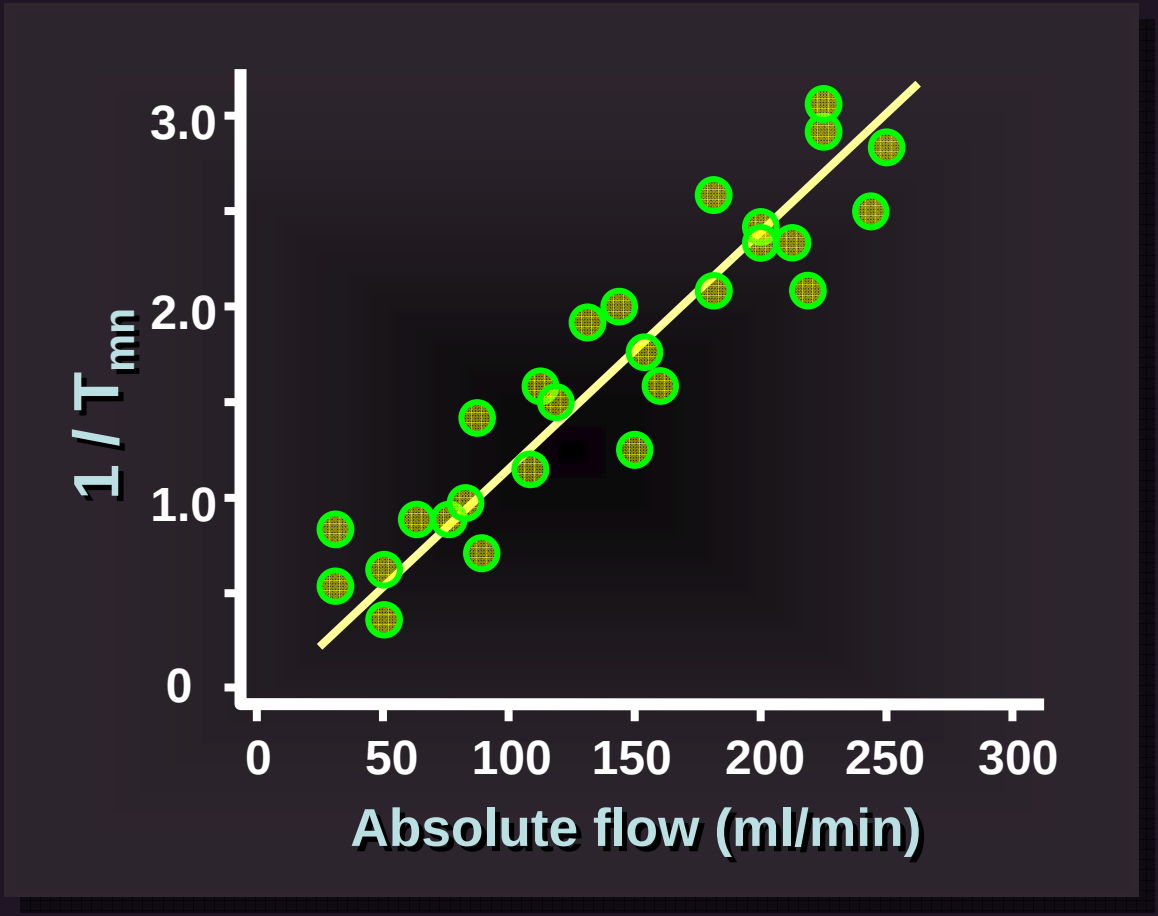


Measurement of IMR



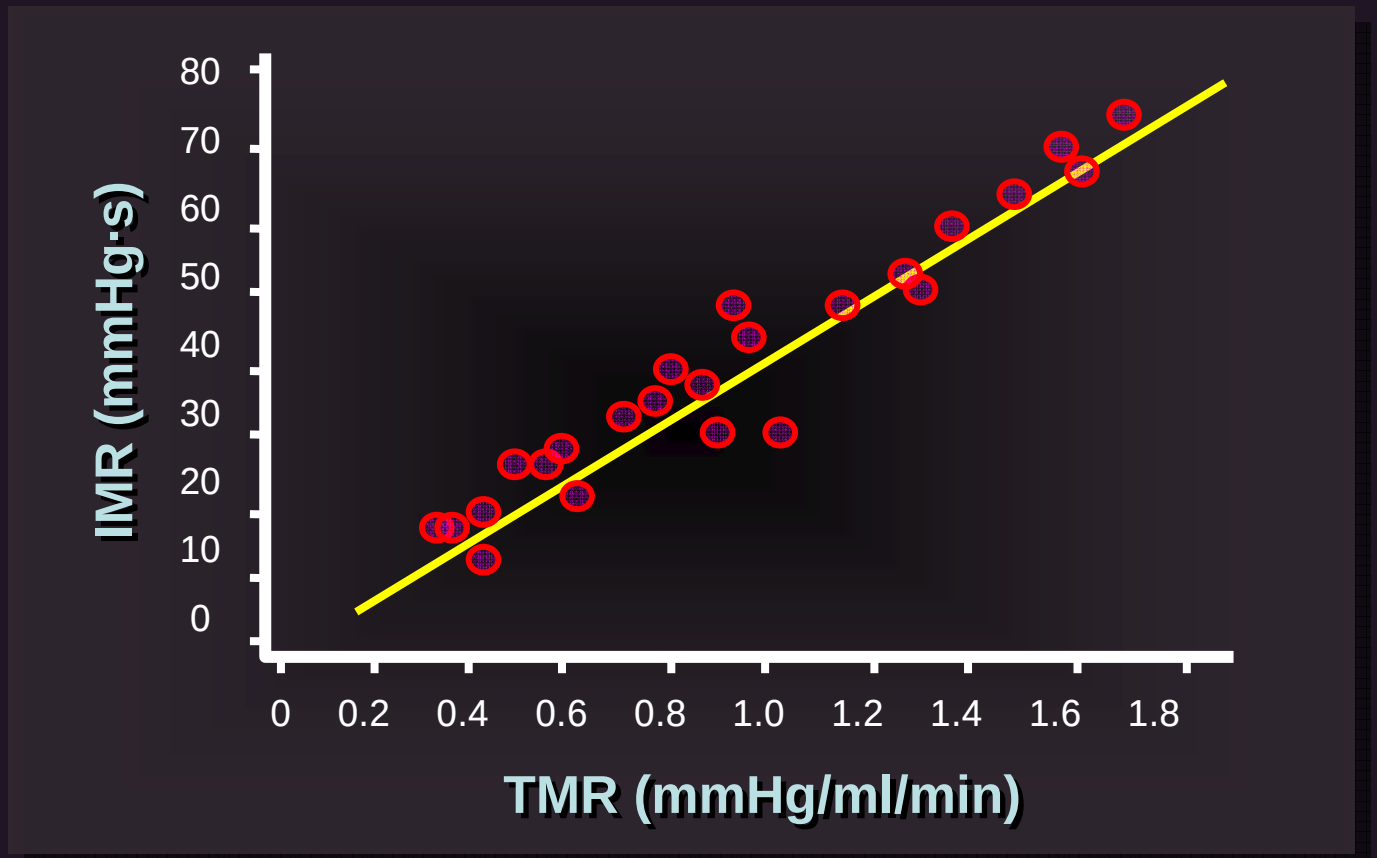
IMR

Derivation of Index of Microcirculatory Resistance (IMR)



IMR

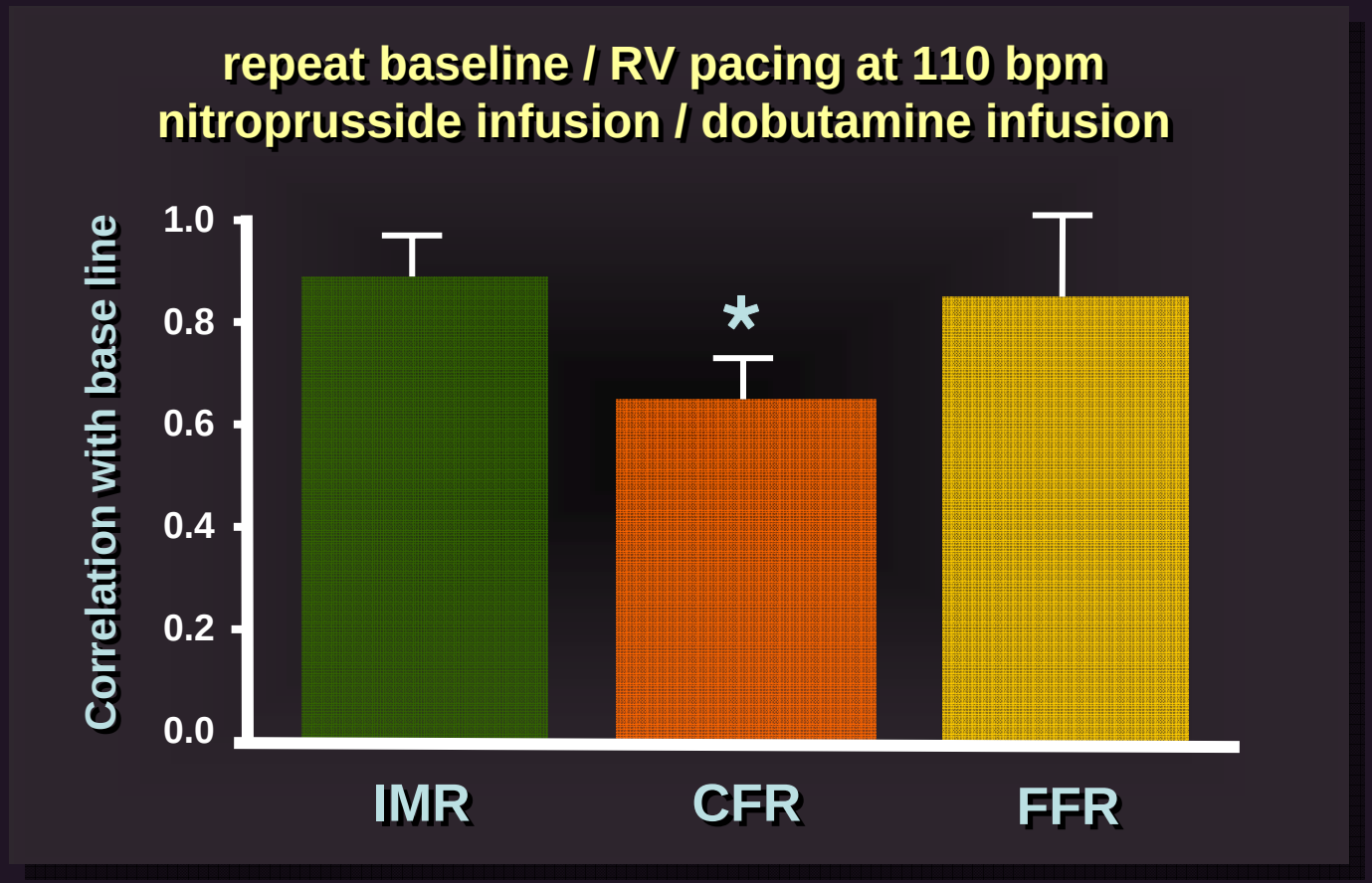
Correlation between IMR and TMR at 24 different combinations of myocardial resistance and epicardial stenosis severity



Aarnoudse, Fearon et al. *Catheter Cardiovasc Interv.* 2004;62(1):56-63.

Reproducibility of IMR

Mean correlation coefficients of IMR, CFR, FFR values comparing baseline measurements with each hemodynamic intervention



Martin et al. *Circulation* 2006;113;2054-2061

Microvascular Integrity in AMI

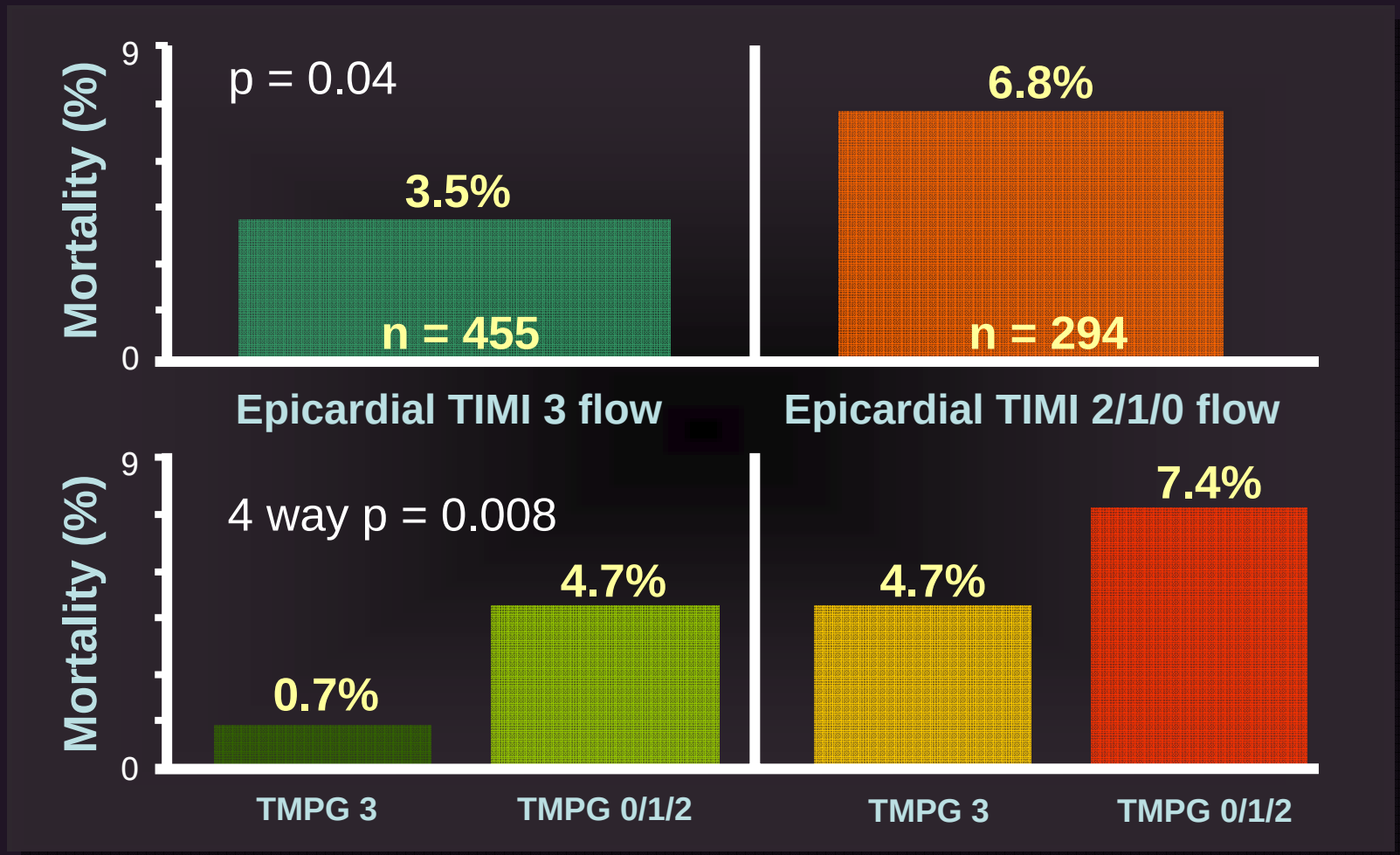
- The preservation of the microvascular functions (microvascular integrity) is an important determinants of improvement of the left ventricular function and clinical outcomes after PCI in AMI.

- The indices of microvascular integrity were related with clinical outcomes of AMI patients.
  - Coronary flow reserve,
  - Phasic coronary flow velocity pattern,
  - Microvascular resistance index

    : Index of microvascular resistance (IMR)
  - Coronary capillary wedge pressure

Microvascular Integrity

Relationship of both TIMI grade and TMP grade to 30-day mortality



Gibson et al. *Circulation* 2000;101;125-130

Microvascular Integrity

- After successful primary PCI for AMI, **CFR** performed before discharge was correlated with ^{201}Tl SPECT redistribution patterns and late LV contractility recovery.

  F. Beygui et al., J Am Coll Cardiol 2002;40:877

- **Phasic Coronary flow velocity parameters or patterns** is useful in predicting recovery of regional LV function.
  - Deceleration time of diastolic flow velocity (DDT) > 600ms
  - Systolic average peak velocity (SAPV) > 6.5 cm/sec

  Akasaka et al. Circulation 1999;100:339

Microvascular Integrity

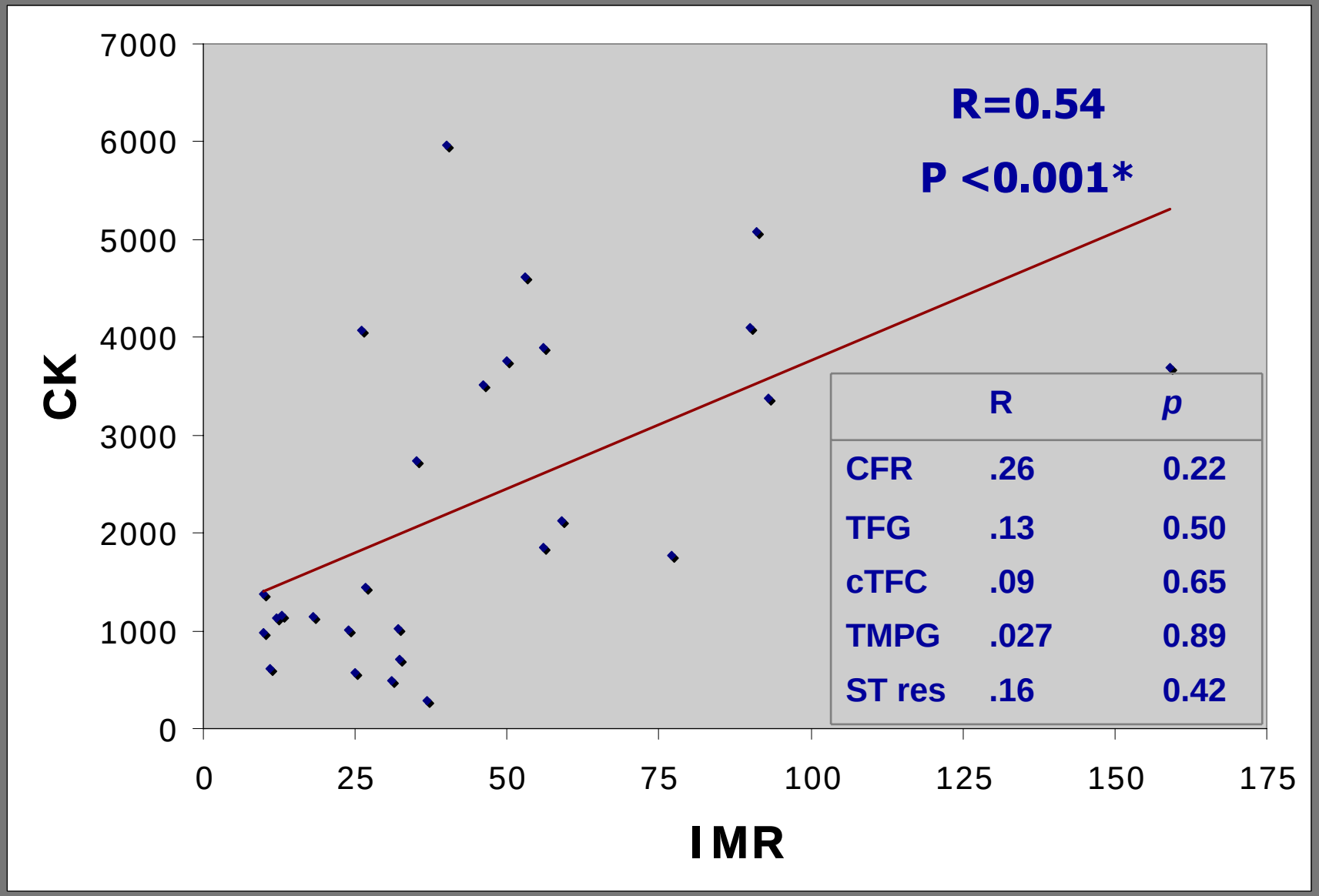
- The parameter that correlates best with residual myocardial viability is coronary wedge pressure (**Pcw**) and this may be a useful index for predicting patient prognosis.

Shimada et al. Heart 2003;89:71–76

- In AMI, collateral flow index (**CFIp**) seems to increase with the severity of microvascular dysfunction. Because higher CFIp was associated with poorer functional recovery, it provides a simple and useful estimate of clinical outcomes in AMI.

Yamamoto et al. J Am Coll Cardiol 2001;38:1383-9

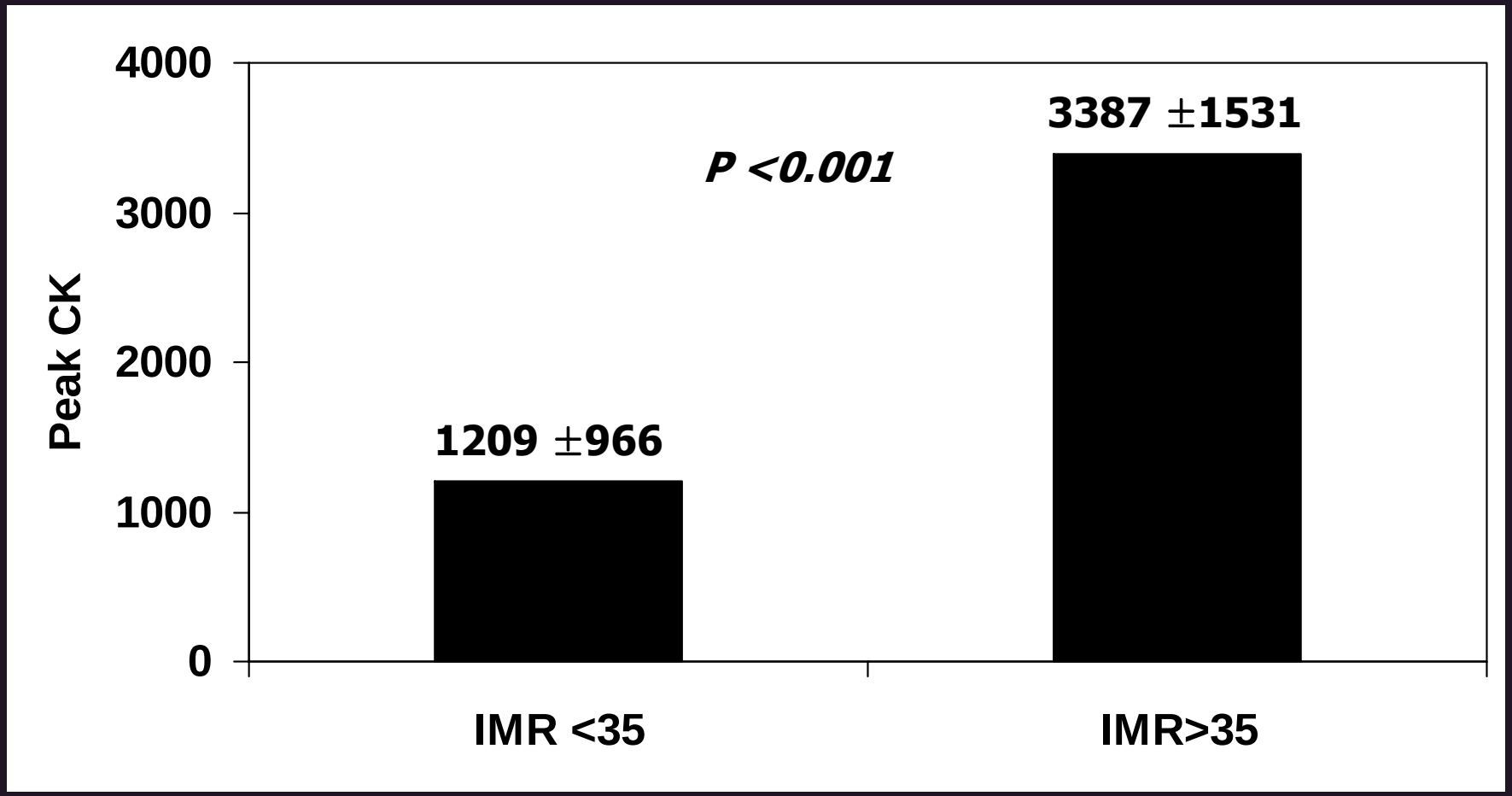
Correlation between IMR and Peak CK



	R	*p*
CFR	.26	0.22
TFG	.13	0.50
cTFC	.09	0.65
TMPG	.027	0.89
ST res	.16	0.42

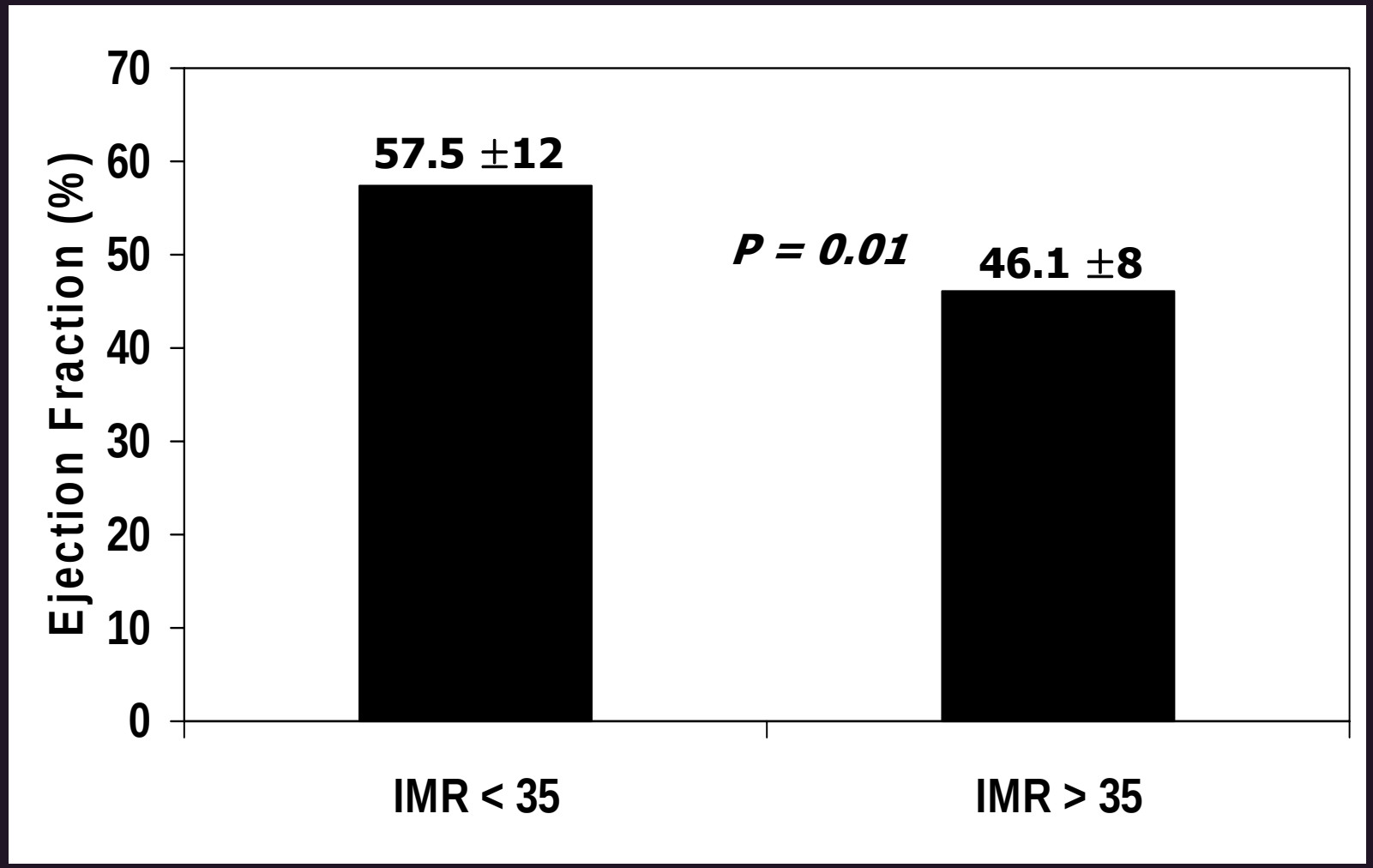
Shah et al. AHA 2006

Peak CK and IMR



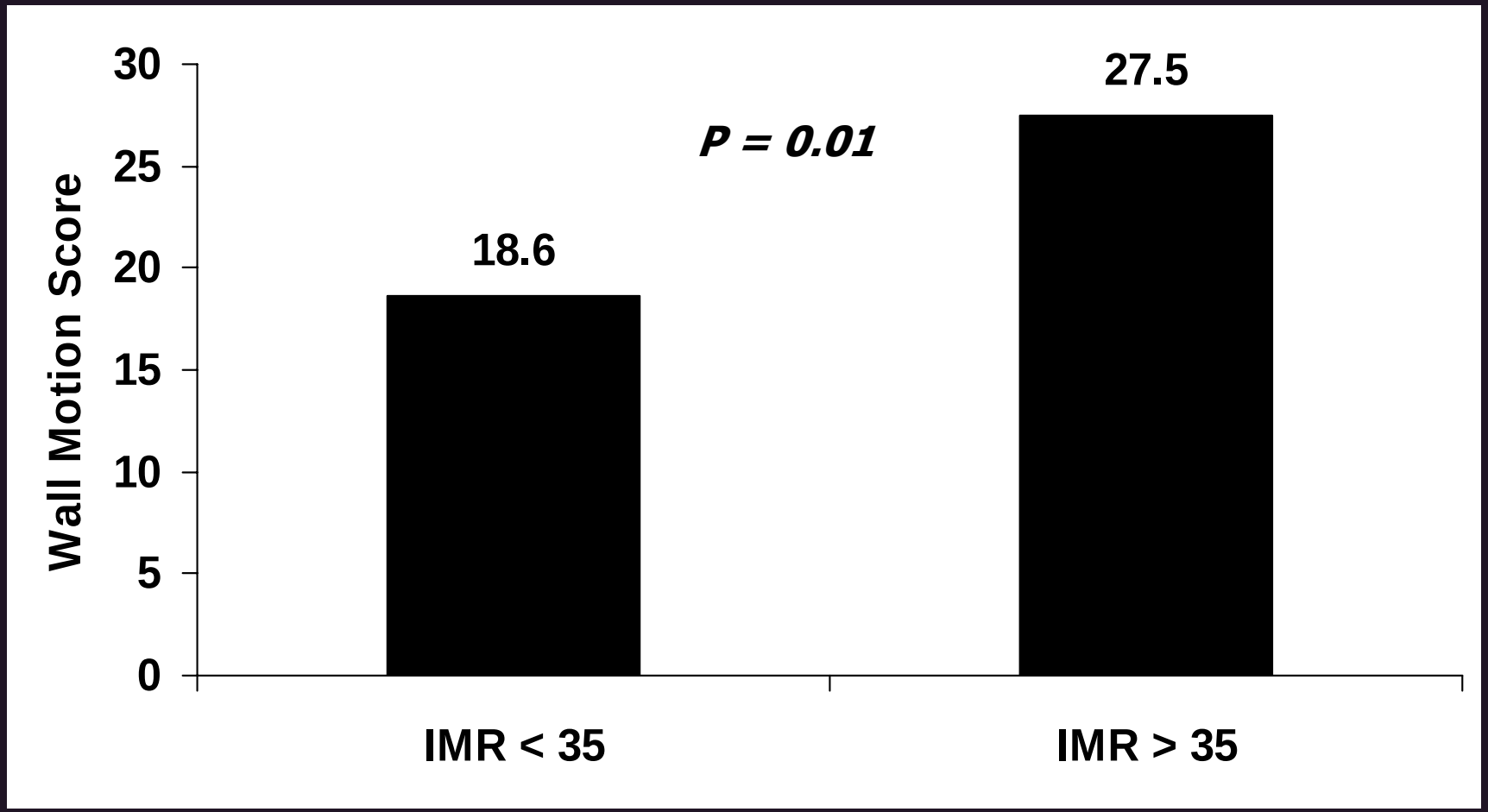
Shah et al. AHA 2006

Follow-Up Ejection Fraction and IMR



Shah et al. AHA 2006

Follow-Up Echo Wall Motion Score and IMR



Shah et al. AHA 2006

IMR and Microvascular Damages

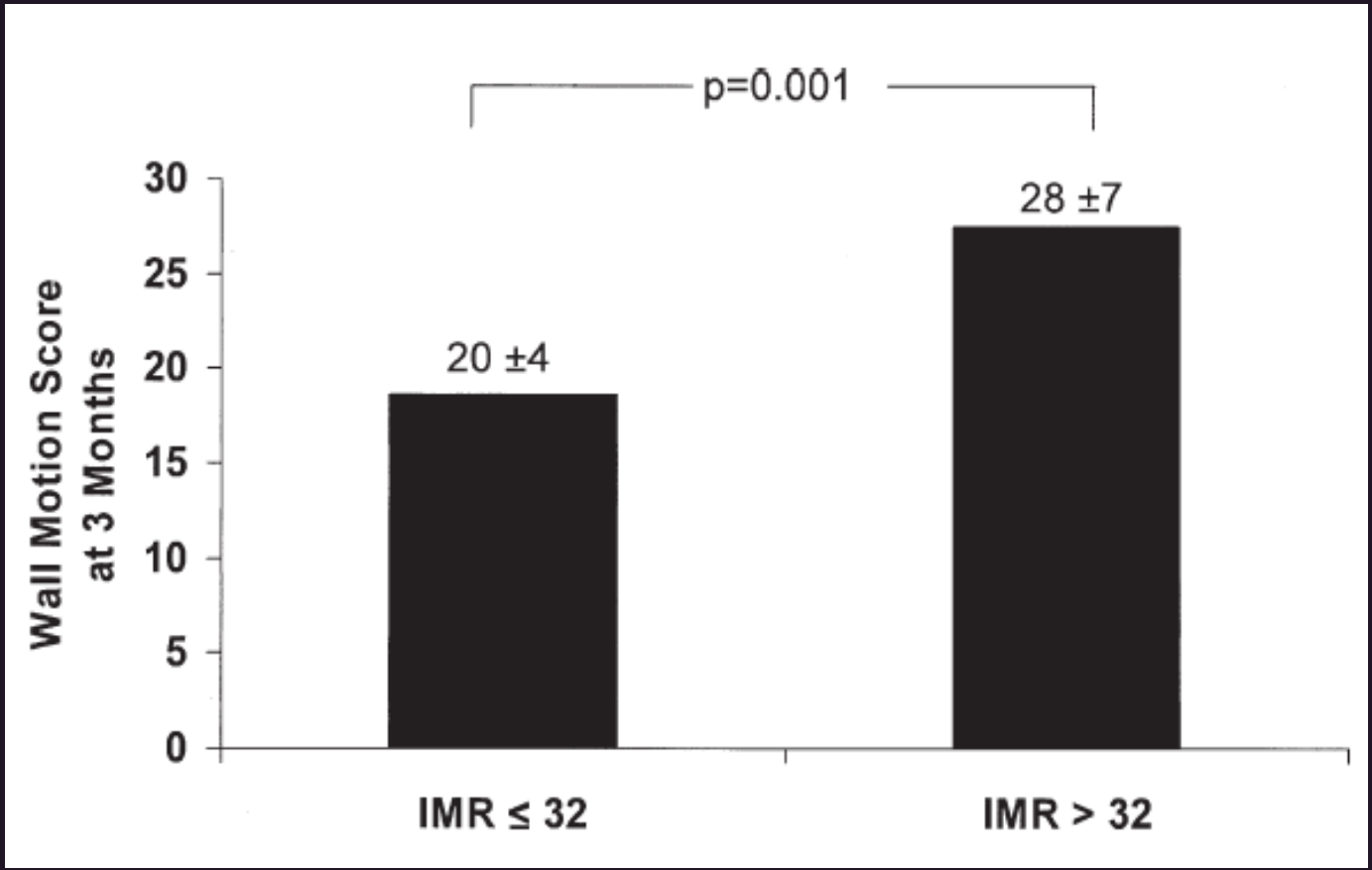
- **Twenty-nine patients with STEMI treated with primary stenting.**

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

- **IMR above the median level of 32 had greater peak CK (3128±1634 vs. 1201±911 IU, p=0.002)**

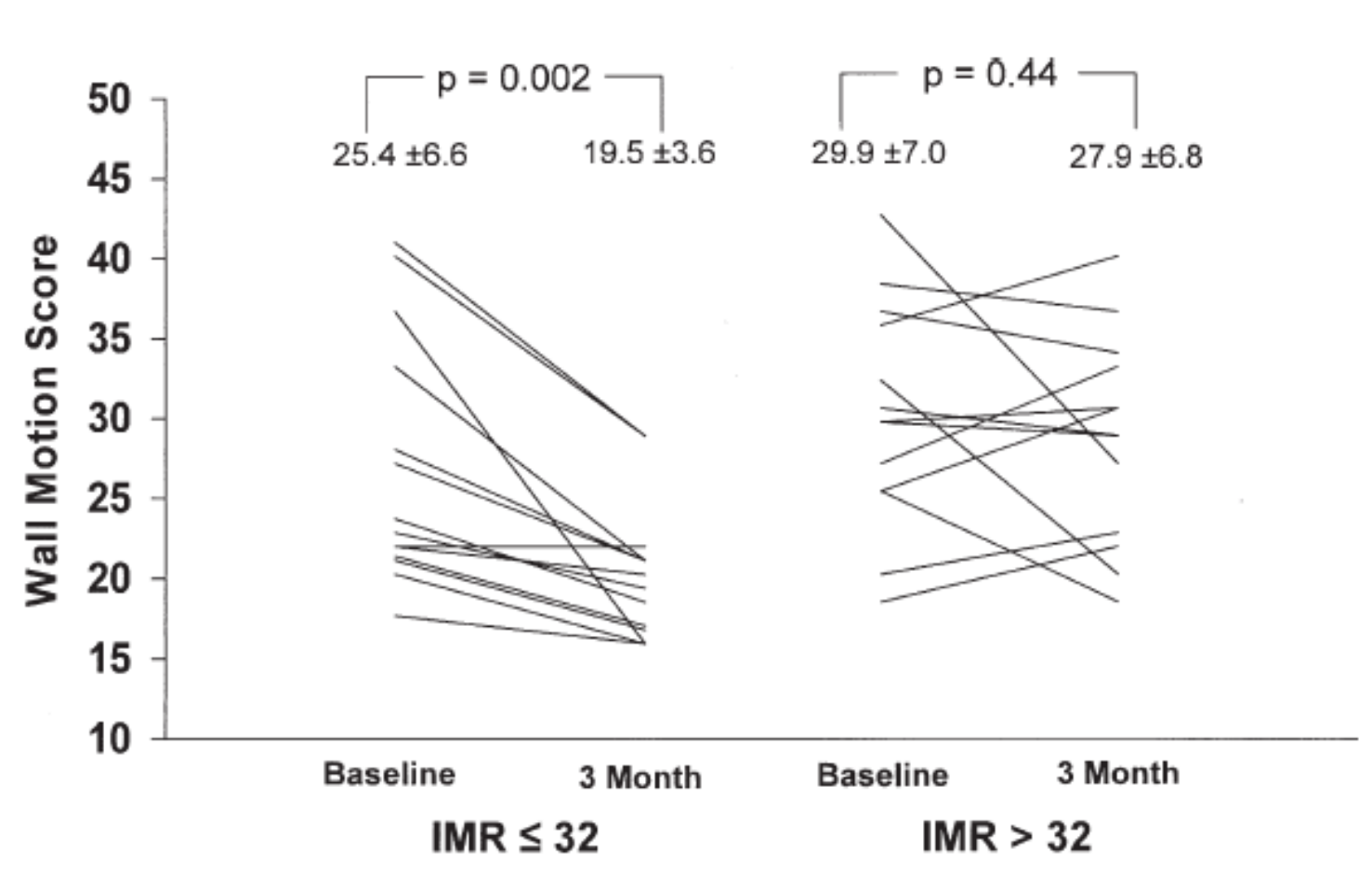
Fearon W et al. J Am Coll Cardiol 2008;51:560–5

Three-Month Wall Motion Score With Low Versus High IMR



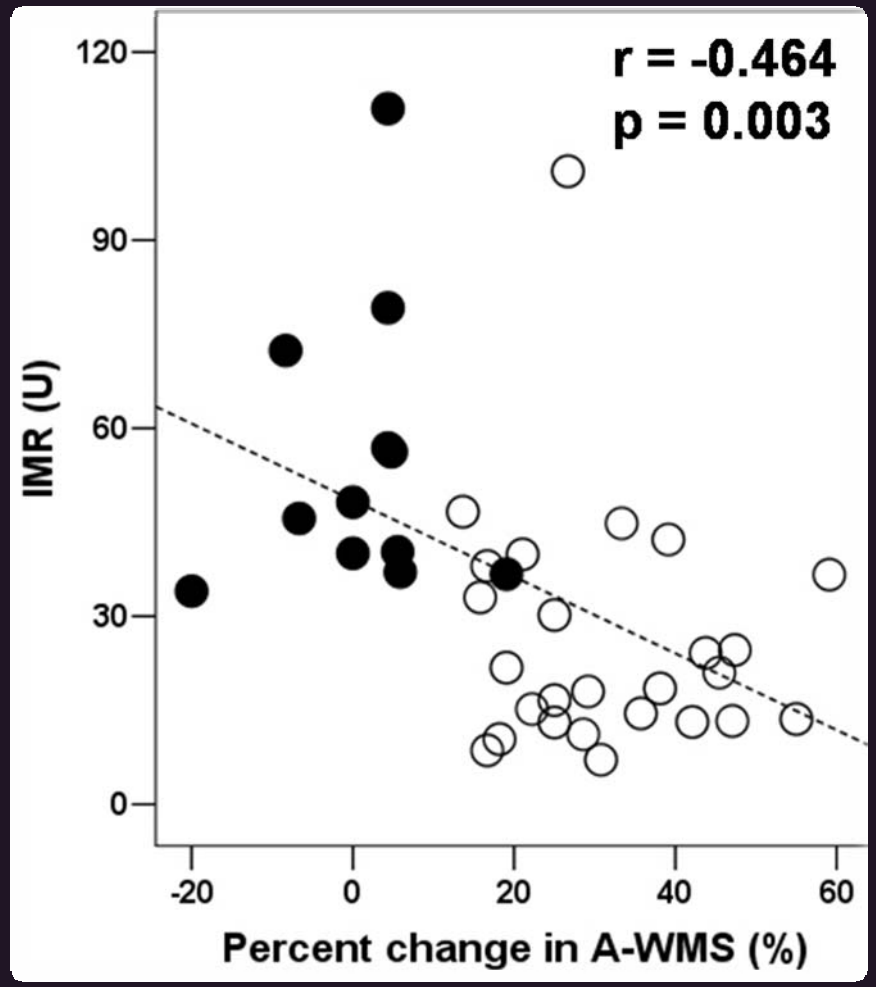
Fearon W et al. J Am Coll Cardiol 2008;51:560–5

Relation Between Change in WMS and IMR



Fearon W et al. J Am Coll Cardiol 2008;51:560–5

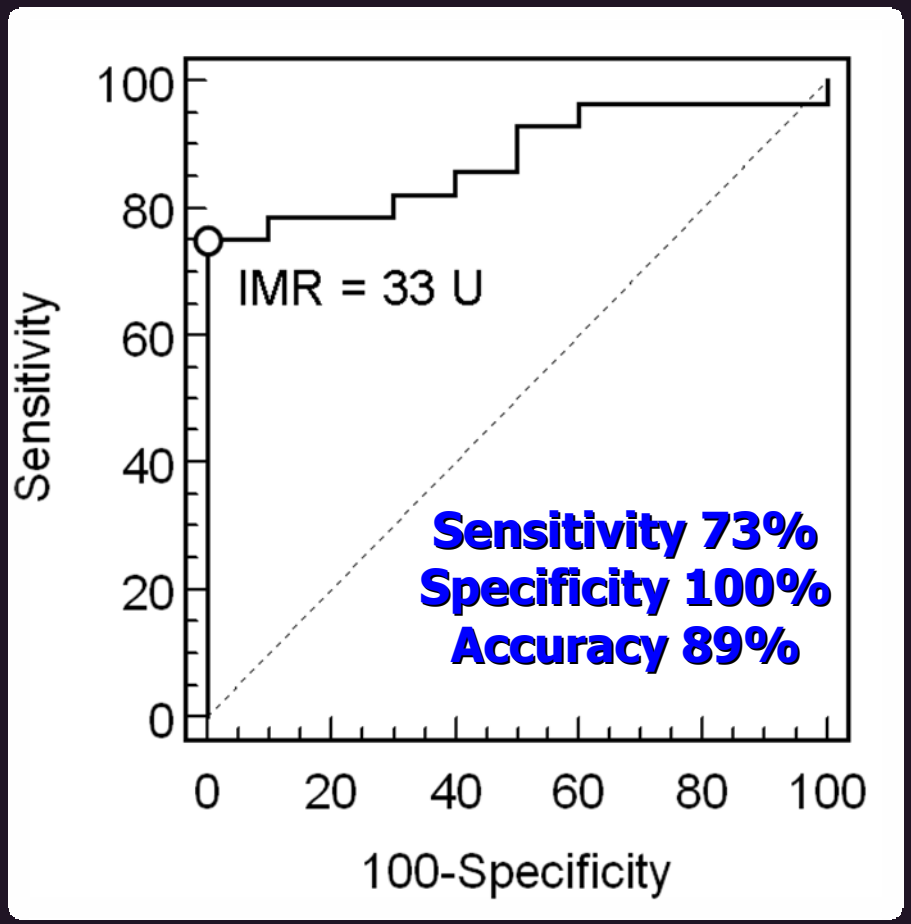
Correlation between the IMR & percent change in A-WMS



● recovery of LV wall motion (–)

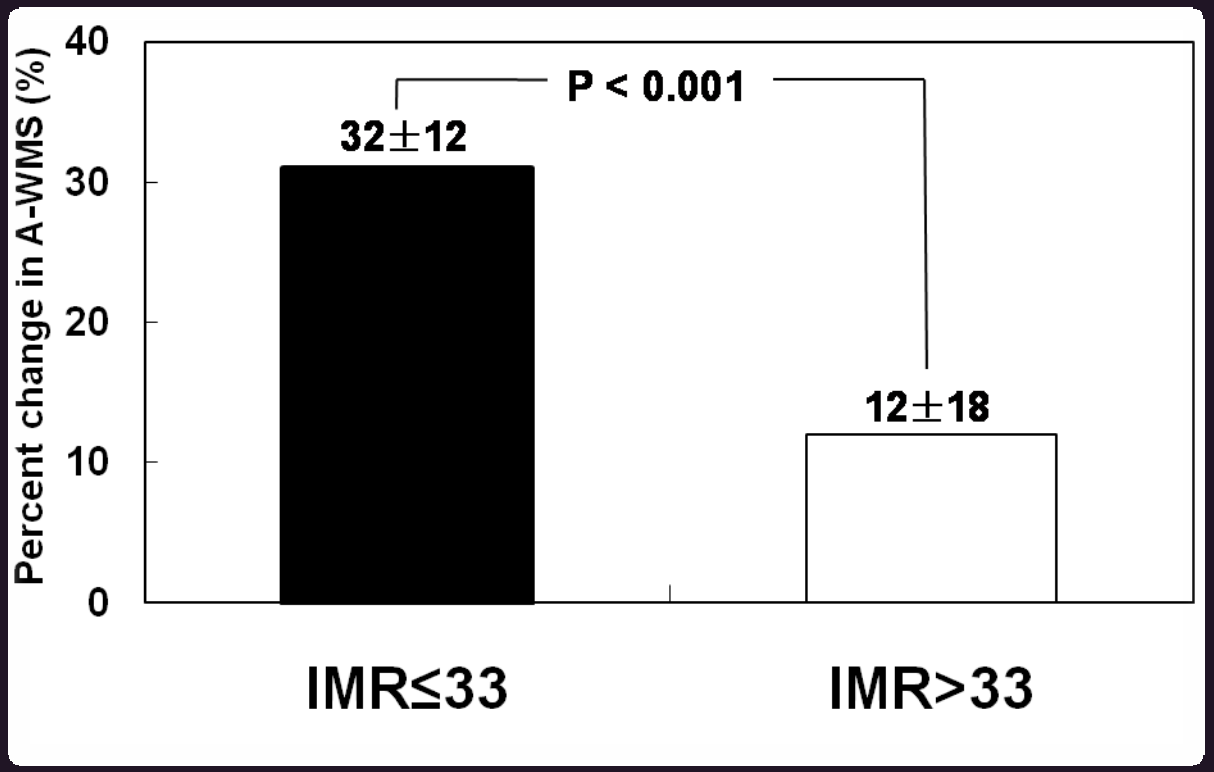
○ recovery of LV wall motion (+)

Cut-off value of the IMR for predicting LV wall motion recovery

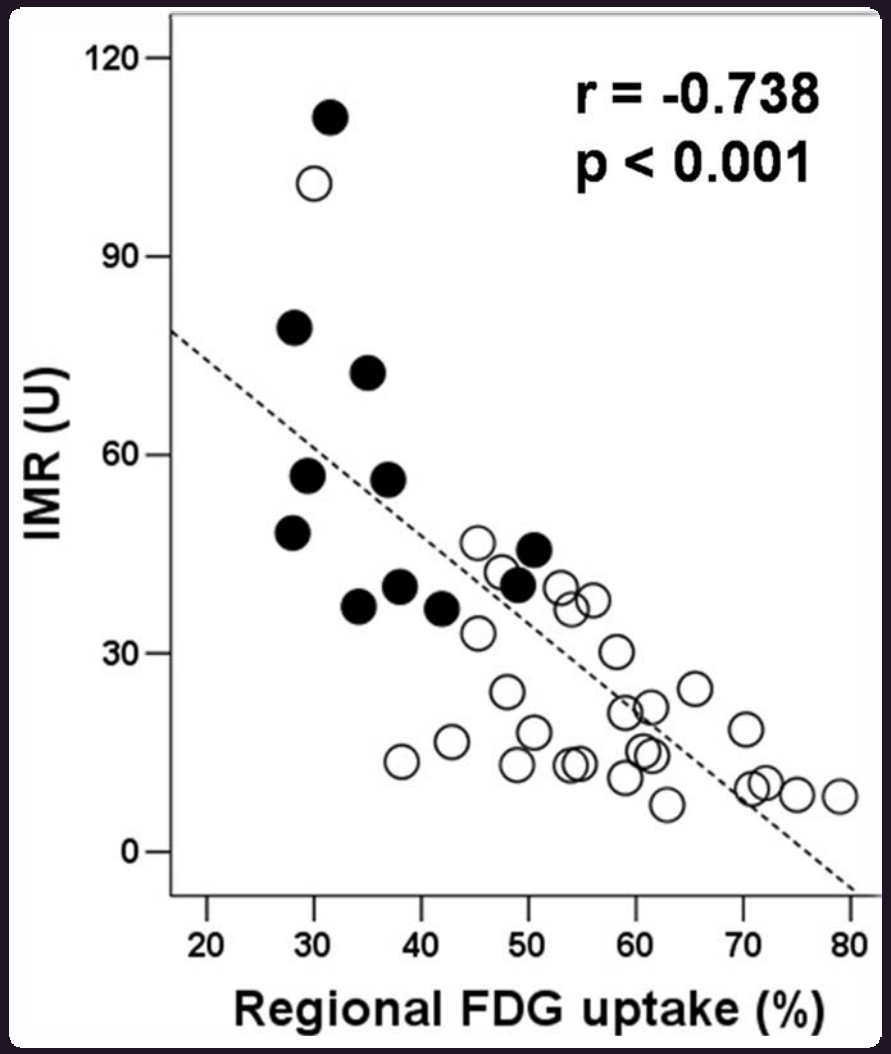


IMR and Changes of WMS

Comparison of percent change in A-WMS in patients presenting with an IMR ≤ 33 U and those presenting with an IMR > 33 U

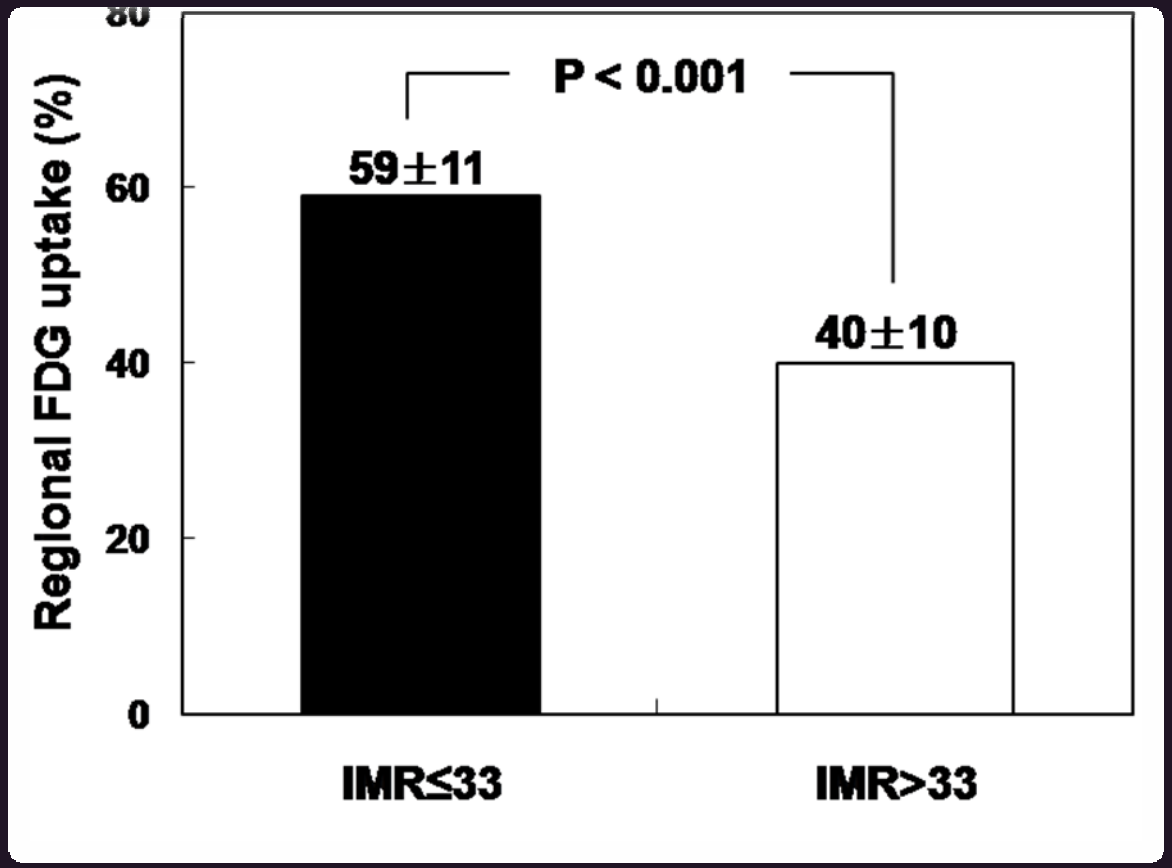


Correlation between the IMR and Regional FDG uptake imaged by PET



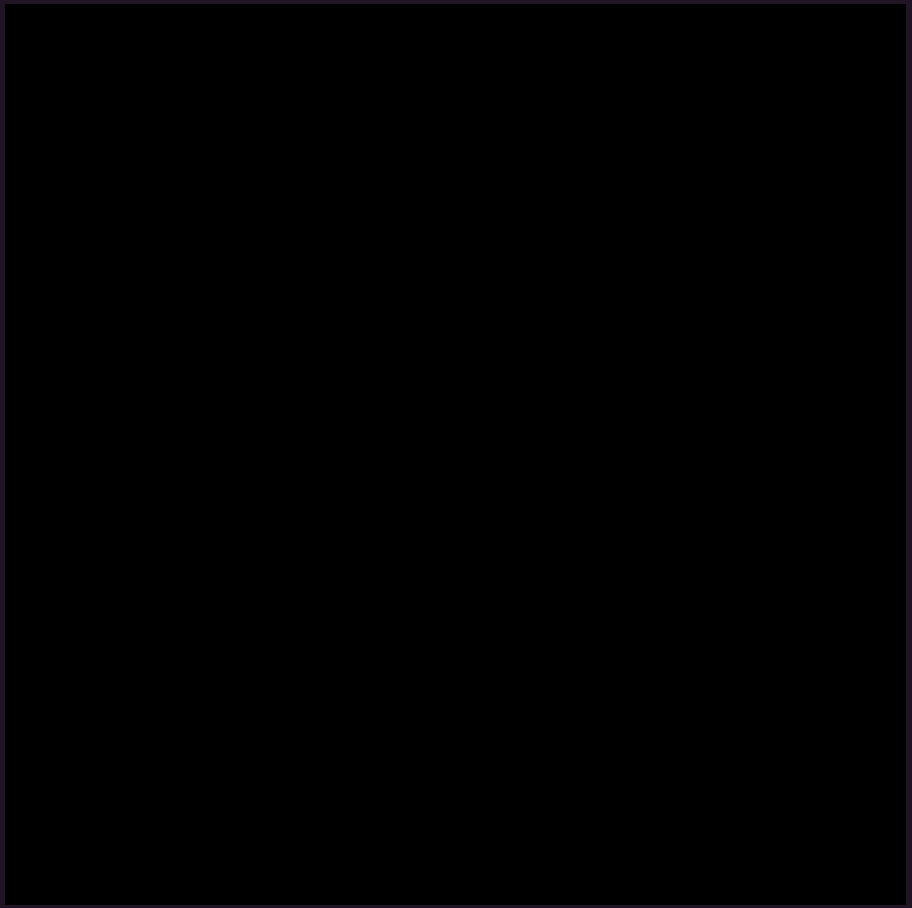
● recovery of LV wall motion (–)
○ recovery of LV wall motion (+)

FDG uptake with an IMR ≤ 33 U and those presenting with an IMR > 33 U

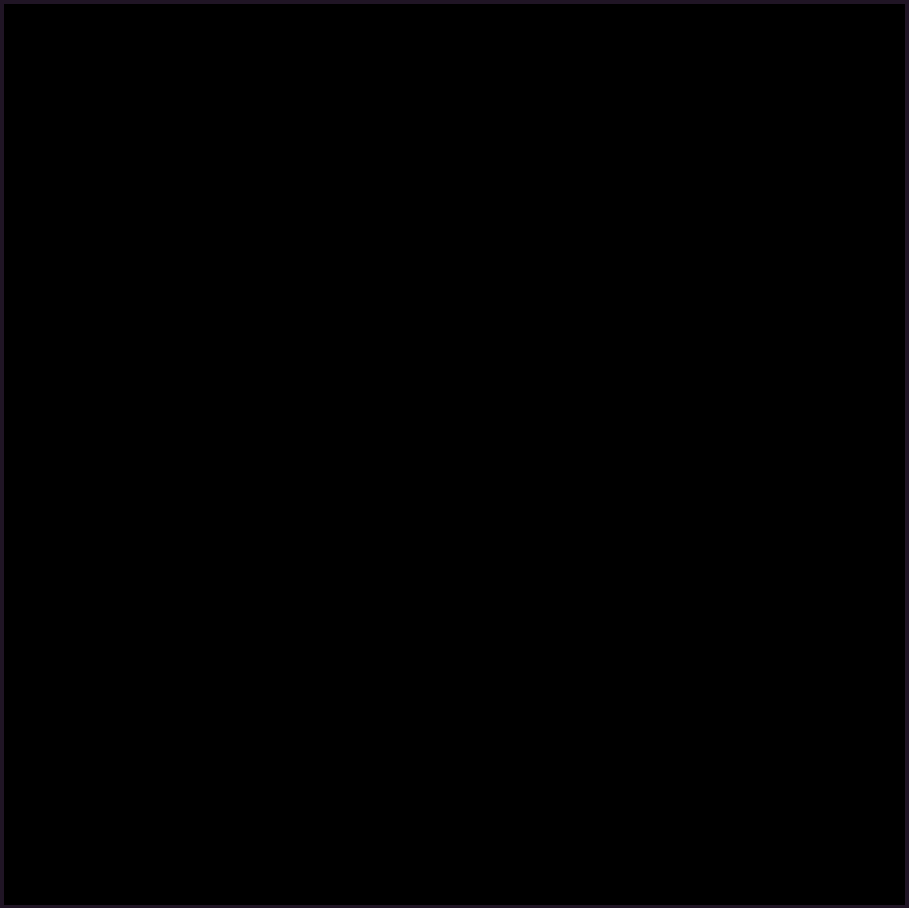


Case 1 : CAG

M/64 STEMI (ant.), onset to balloon time - 120 min



Pre PCI



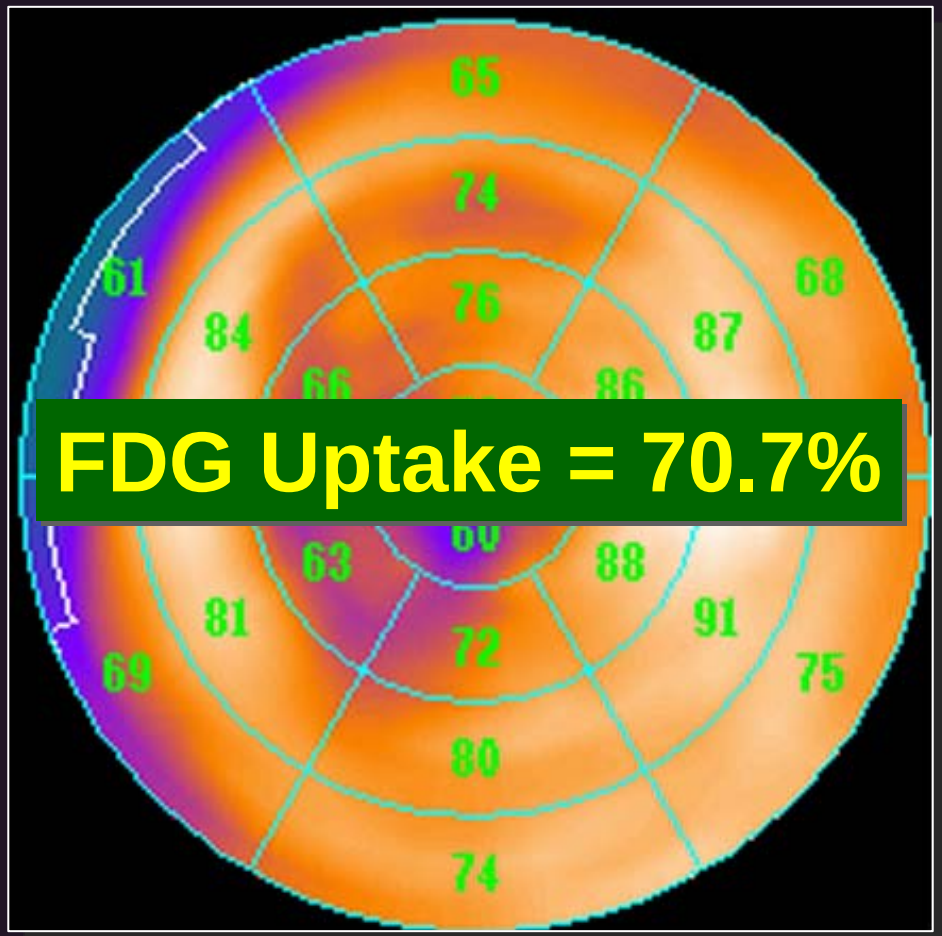
Post PCI

Case 1 : IMR

M/64 STEMI (ant.) **IMR : 11.7 U, CFR_{thermo} : 2.0**

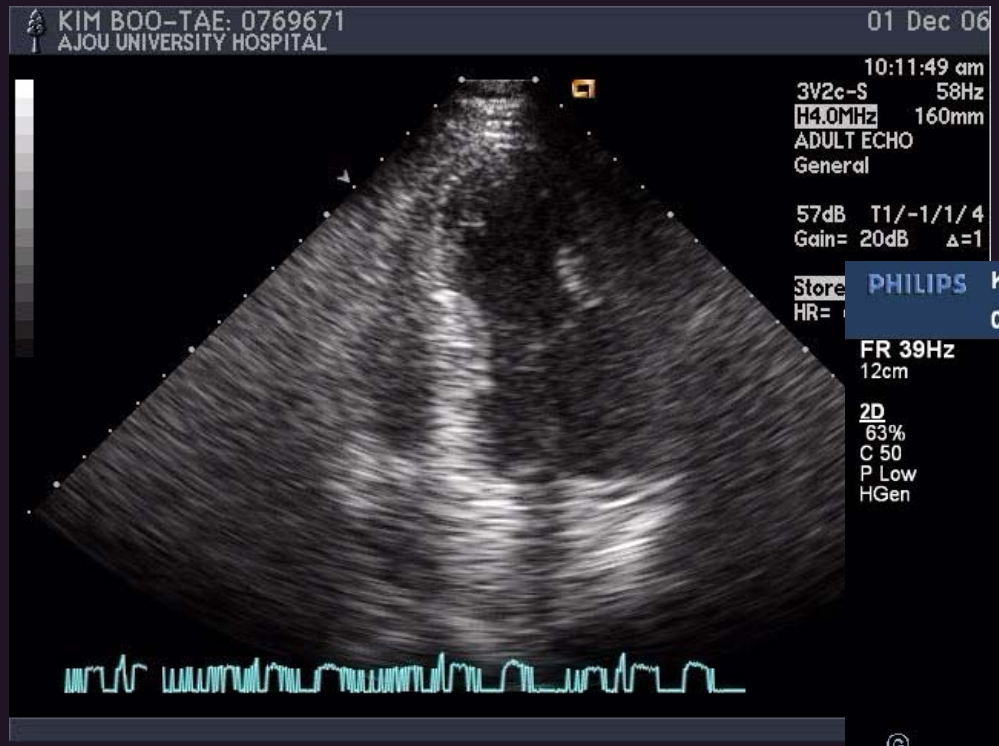
Case 1 : FDG PET

Myocardial Viability : FDG PET



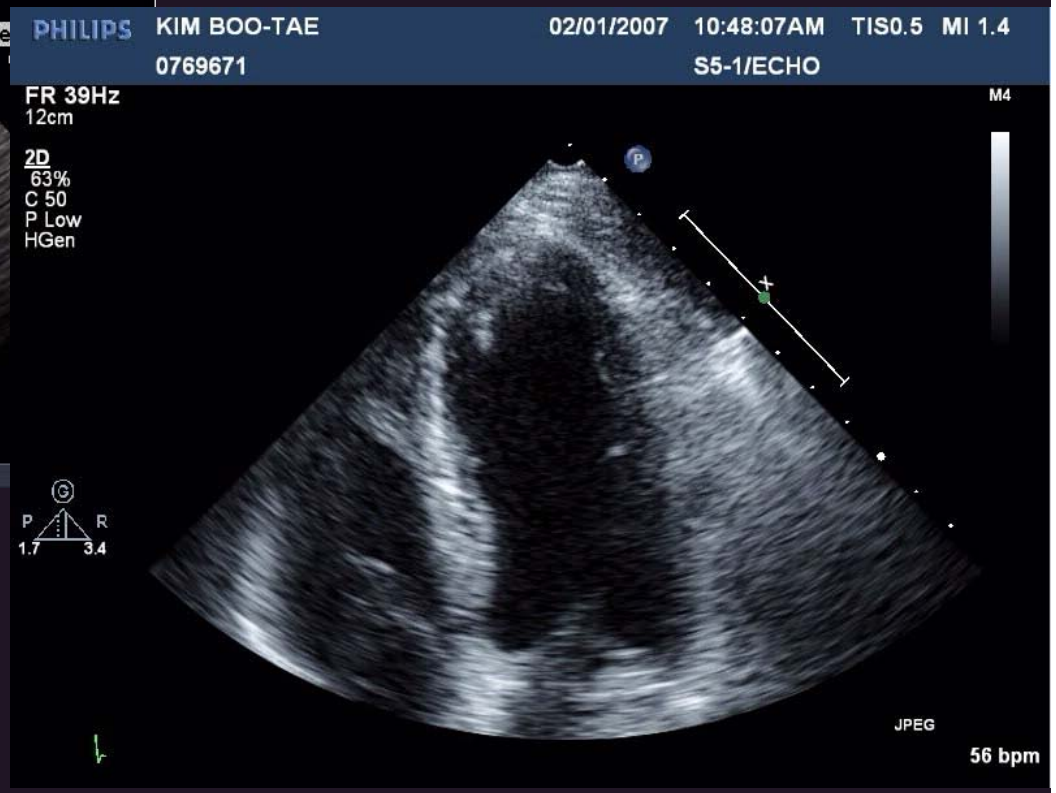
FDG Uptake = 70.7%

Case 1 : Echocardiogram



After primary PCI

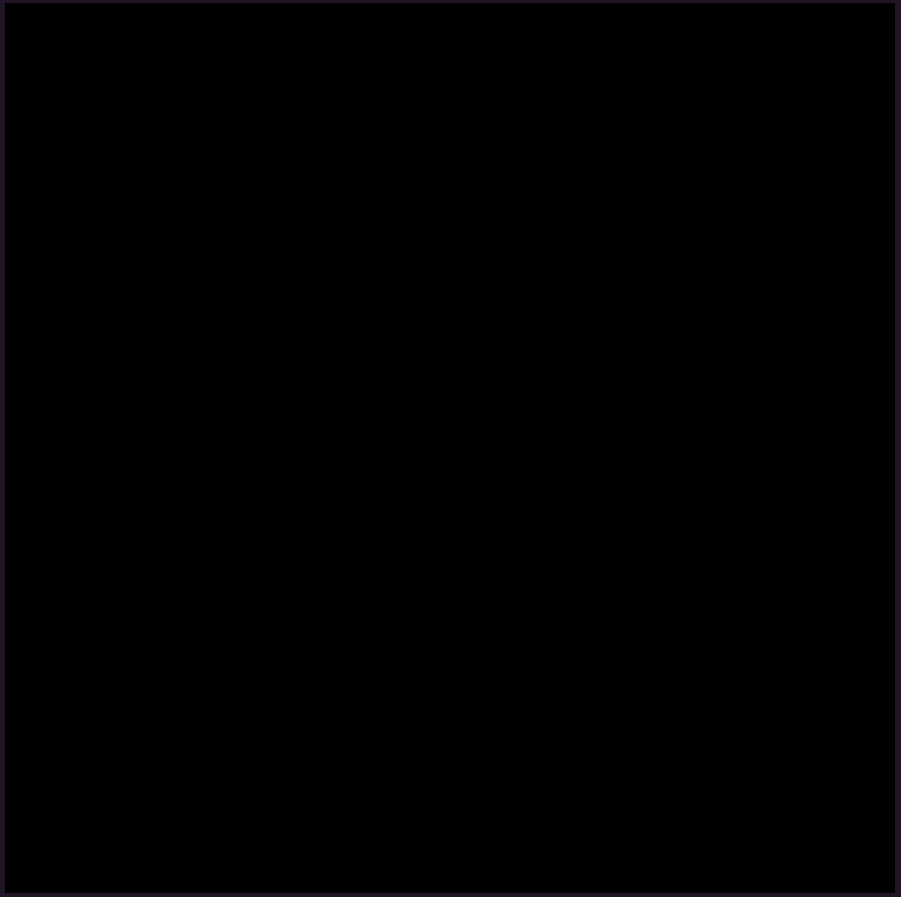
Percent change in A-WMS: 42.1%



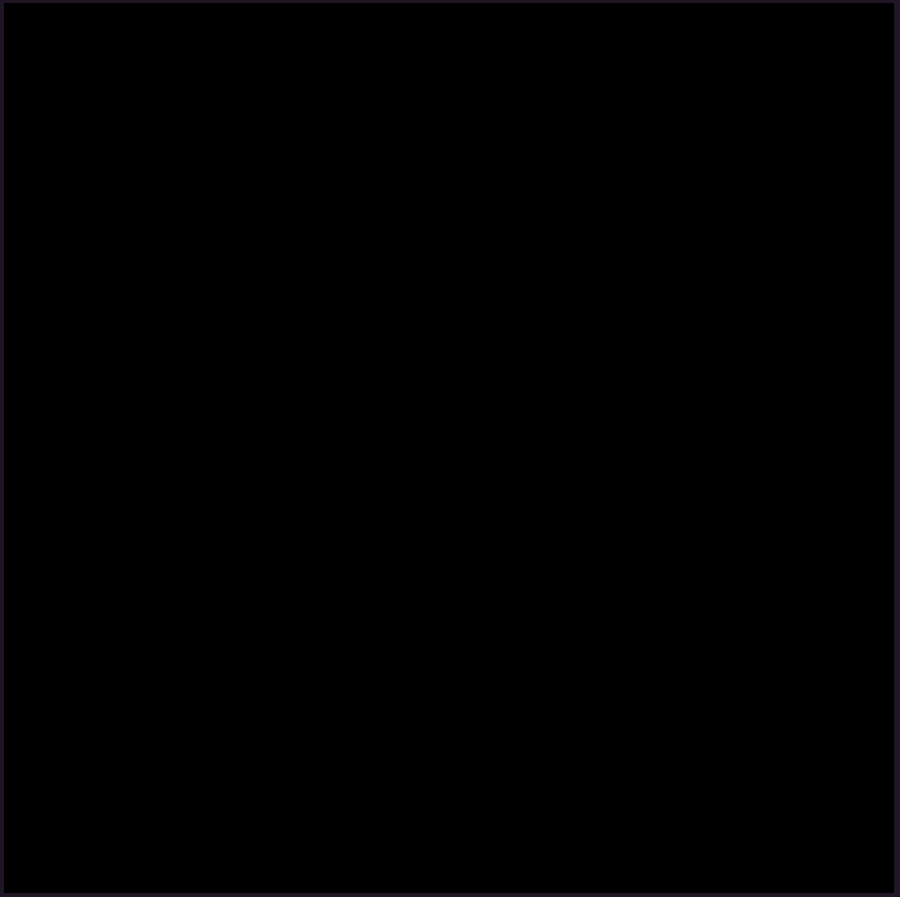
6-mo follow-up

Case 2 : CAG

M/60 STEMI (ant.), onset to balloon time - 600 min



Pre PCI



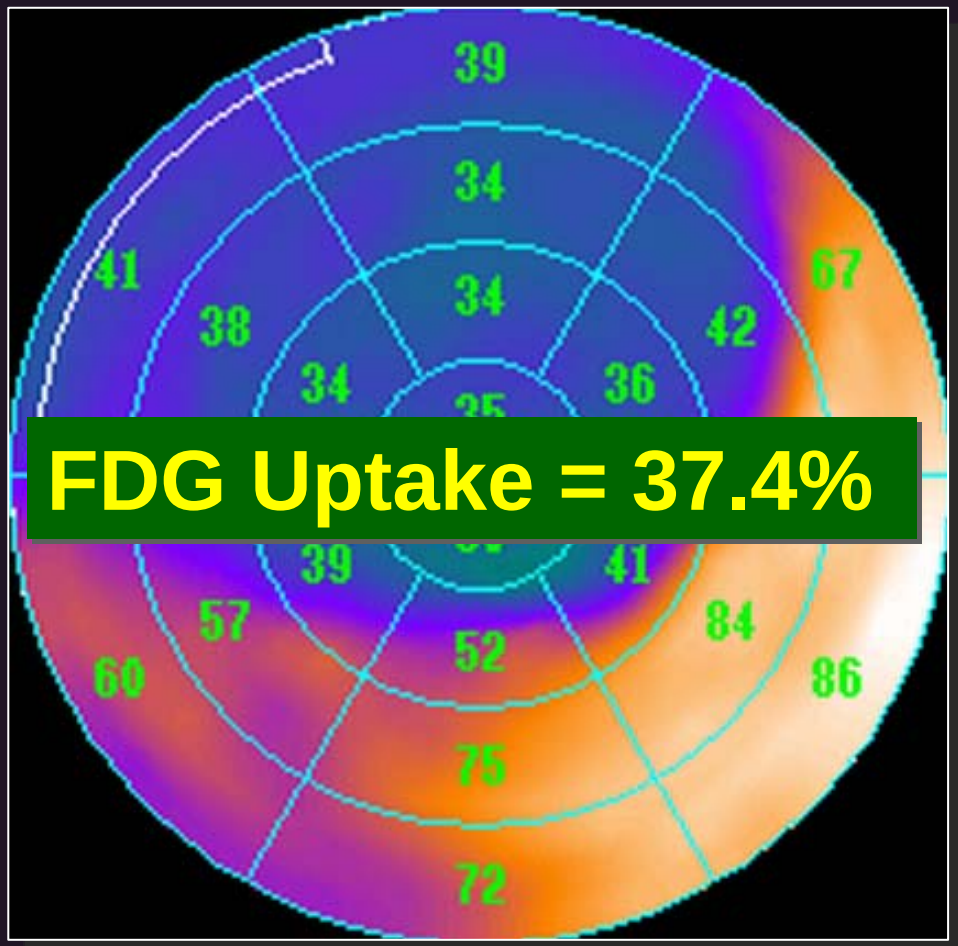
Post PCI

Case 2 : IMR

M/60 STEMI (ant.) **IMR : 72.3 U, CFR_{thermo} : 1.7**

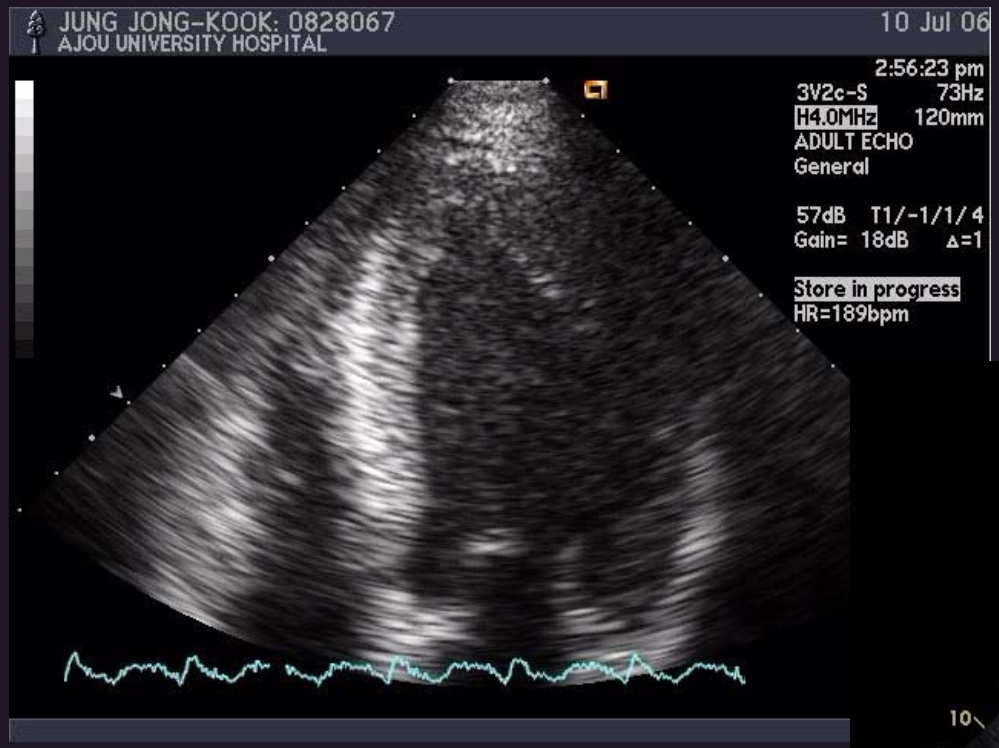
Case 2 : FDG PET

Myocardial Viability : FDG PET



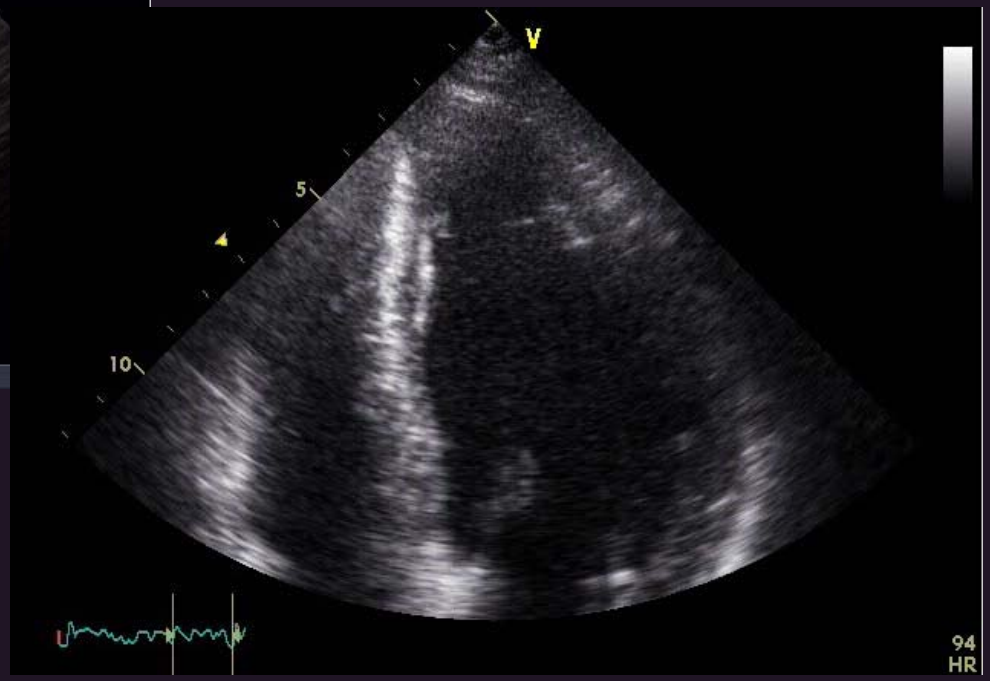
FDG Uptake = 37.4%

Case 2 : Echocardiogram



After primary PCI

Percent change in A-WMS: -8.3%



6-mo follow-up

Advantage of IMR

- Highly reproducible index which is not affected hemodynamic conditons
- IMR has good correlation with absolute coronary blood flow and true microvascular reistance

Limitations of IMR

- Lack of optimal cutoff value about microvascular dysfunction
- Additional procedure for inducing hyperemia
- No large randomized clinical data

Conclusions

IMR, a novel index representing the microvascular integrity, is a reliable parameter for the invasive, on-site assessment of myocardial viability after primary PCI in AMI.

What do interventionists need in clinical practice?

1) Epicardial Vessel→ FFR
2) Microvasculature→ IMR!!

Research Fellow 2009

Dr Ramasamy, Dr Poddar from India

RN, Seo Young Park
Korean Research Fellow, Ji Young Park
Dr Wang from Tianjin, China

Thank You for Your Attention!!

Korea University Guro Hospital

Thank you for your attention !