Evaluation of Microvascular Dysfunction

Takashi Akasaka, MD, PhD
Department of Cardiovascular Medicine
Wakayama Medical University, Japan

TCT imaging & physiology 2008

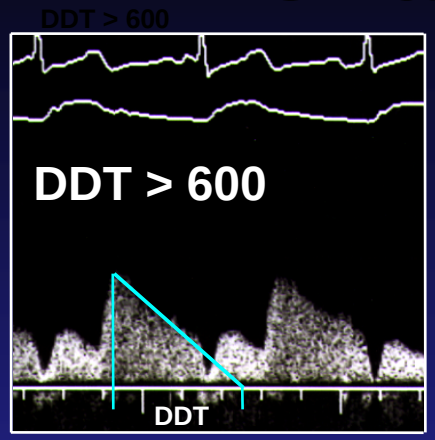
Evaluation of Microvascular Dysfunction

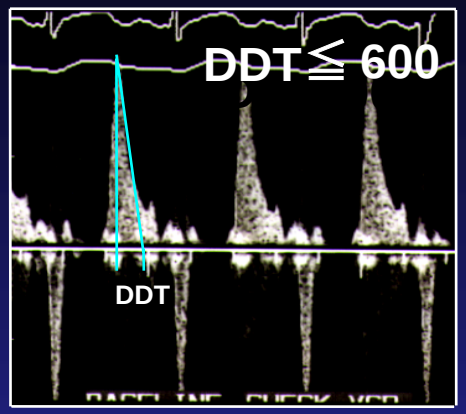
- **Many indexes have been proposed as the predictors demonstrating microvascular condition.**

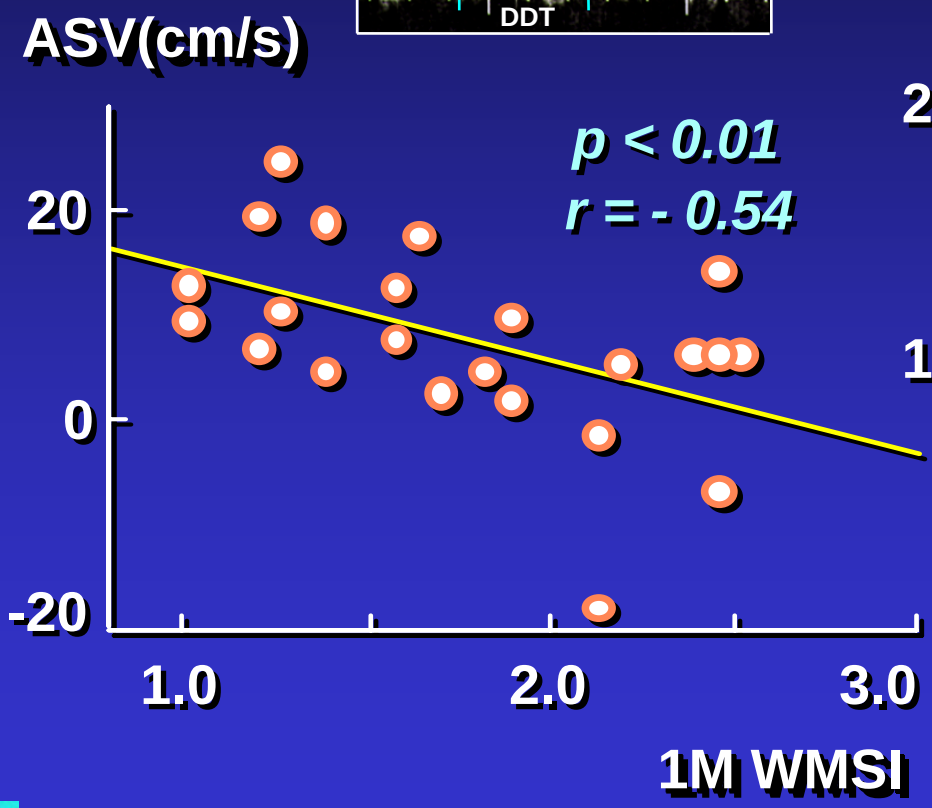
  Coronary flow velocity pattern
  CFR (cornary flow reserve)
  Pzf (Zero flow pressure)
  Qc/Qn, CWP
  MVRI, h-MVr

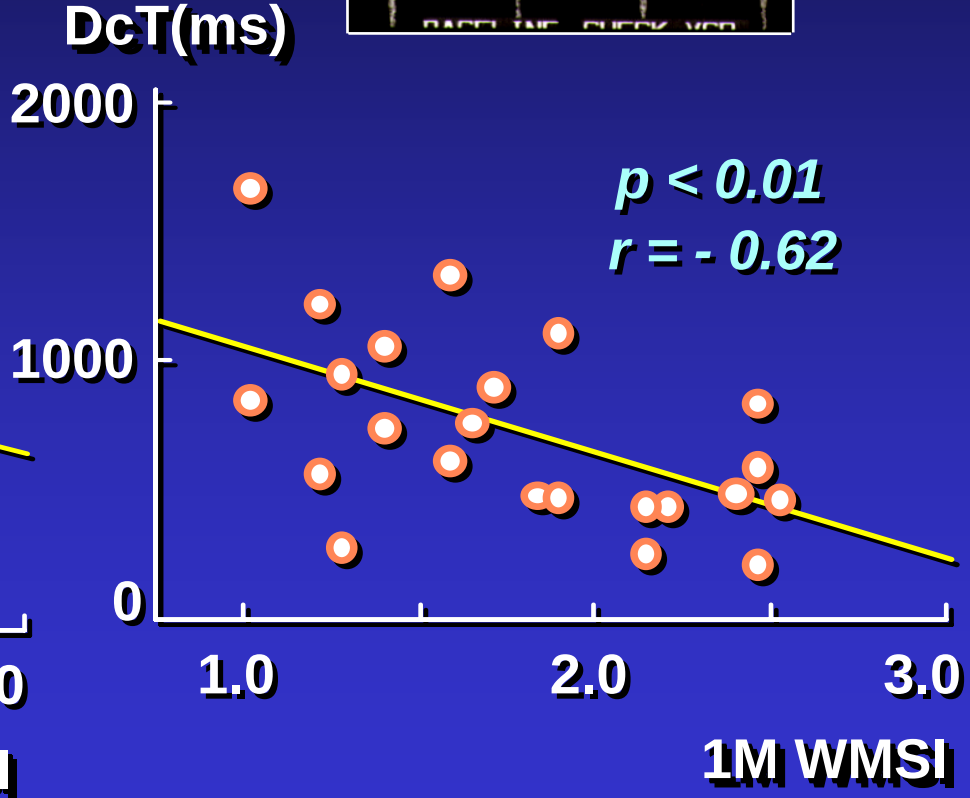
- **Many reports have been focused on the relation between LV function recovery and microvascular dysfunction in AMI.**

ASV & DcT vs LVWMSI



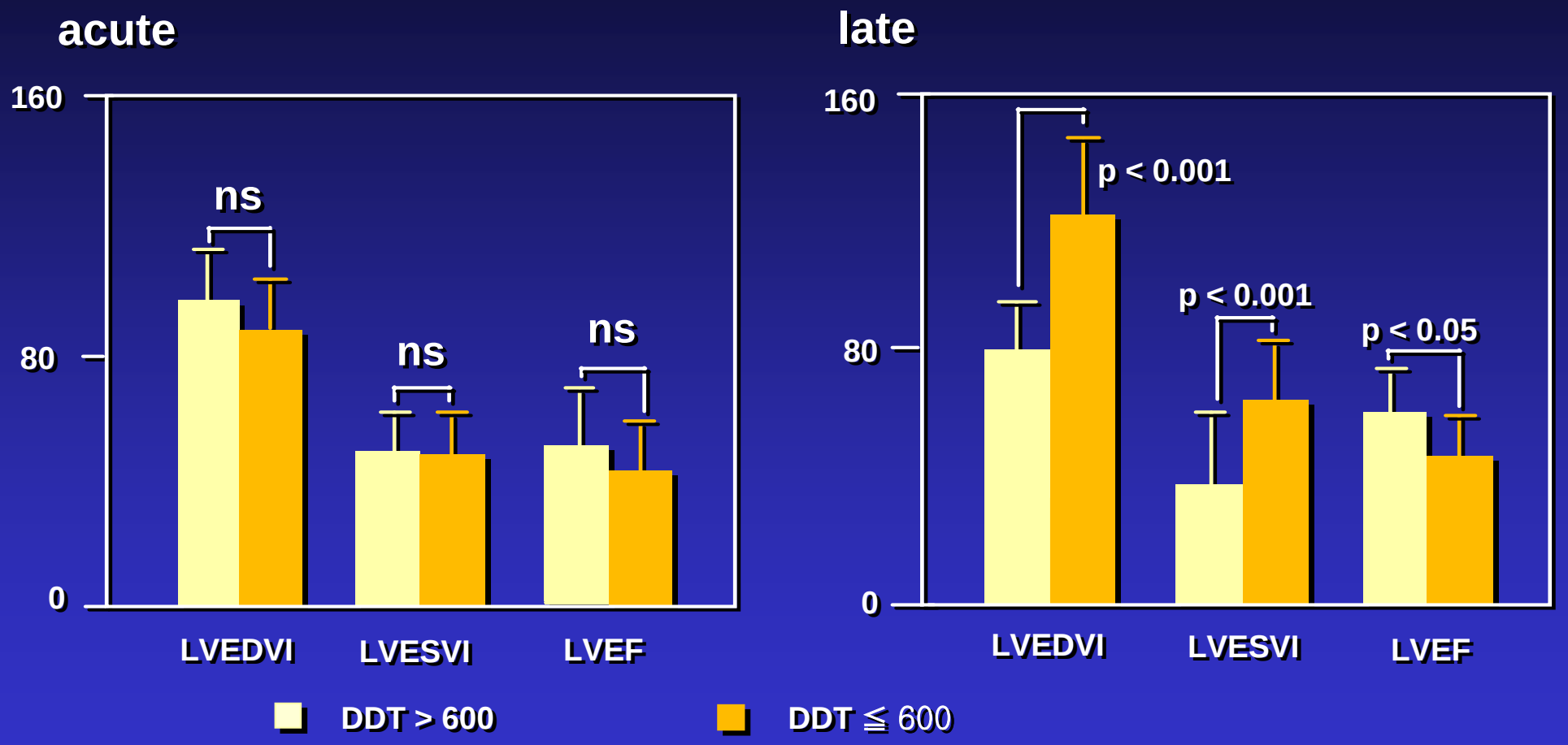






(Kawamoto T, Yoshida K, Akasaka T, et al. Circulation 1999;100: 339-345)

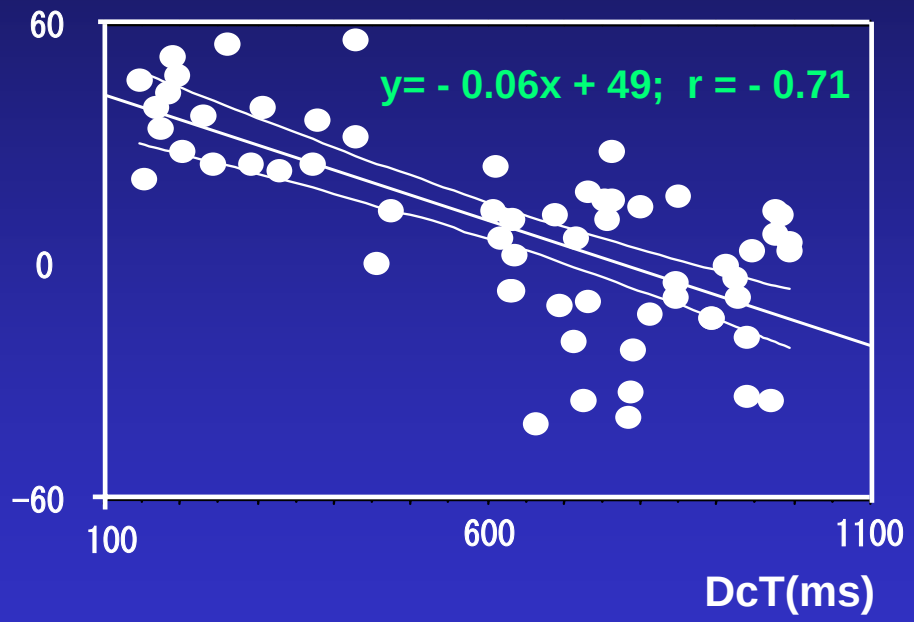
LV volumes and ejection fraction

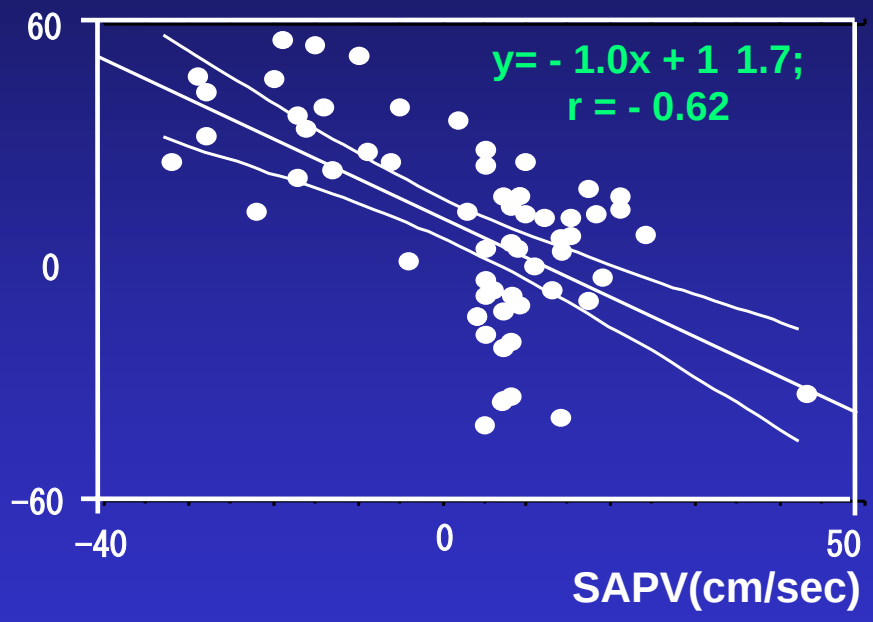


(Yamamuro A, AkasakaT, et al. Circulation 100;144, 1999)

Correlation of Doppler variables of coronary flow with changes of LVEDVI

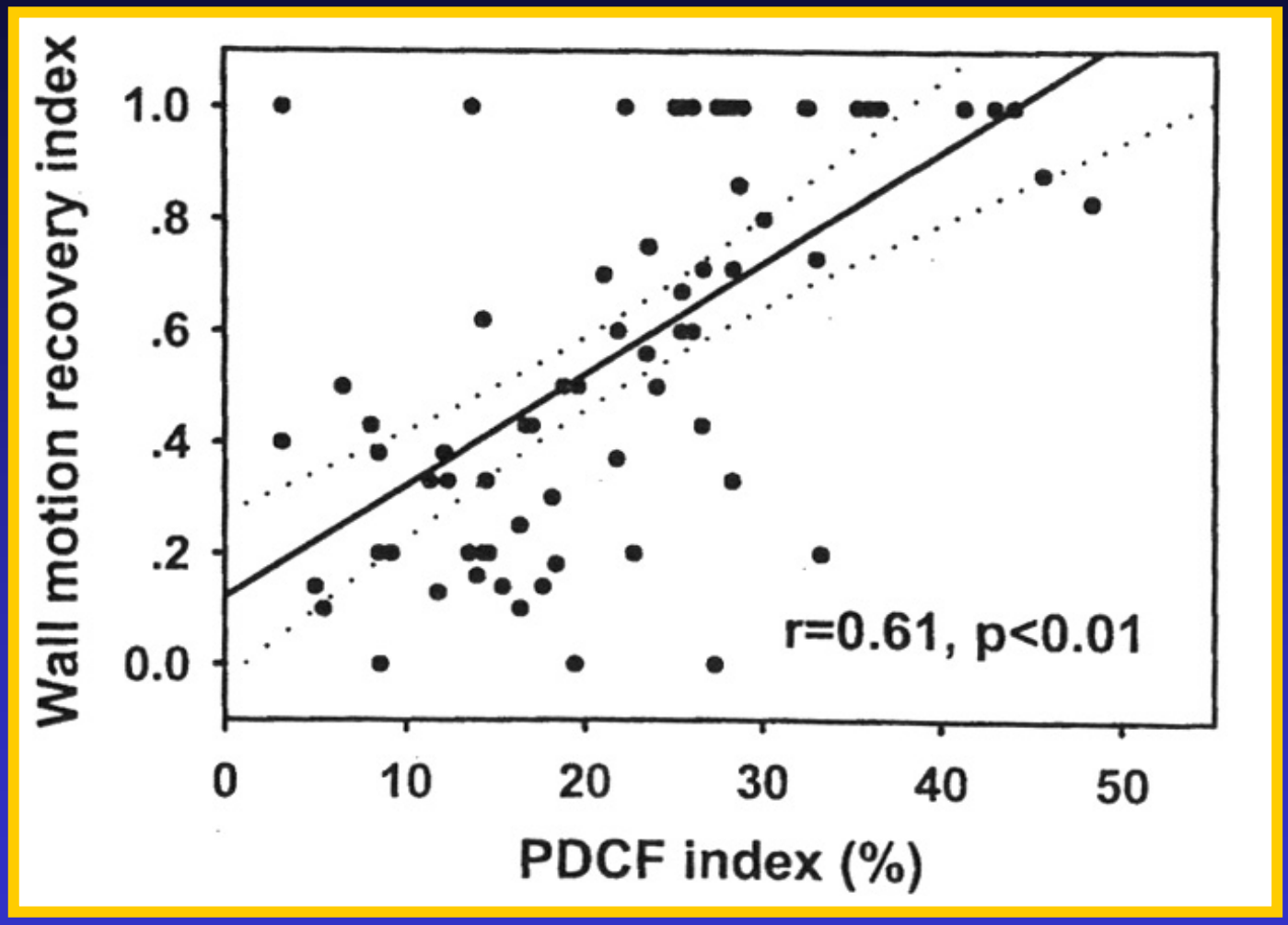
Change in LVEDVI over 6 months





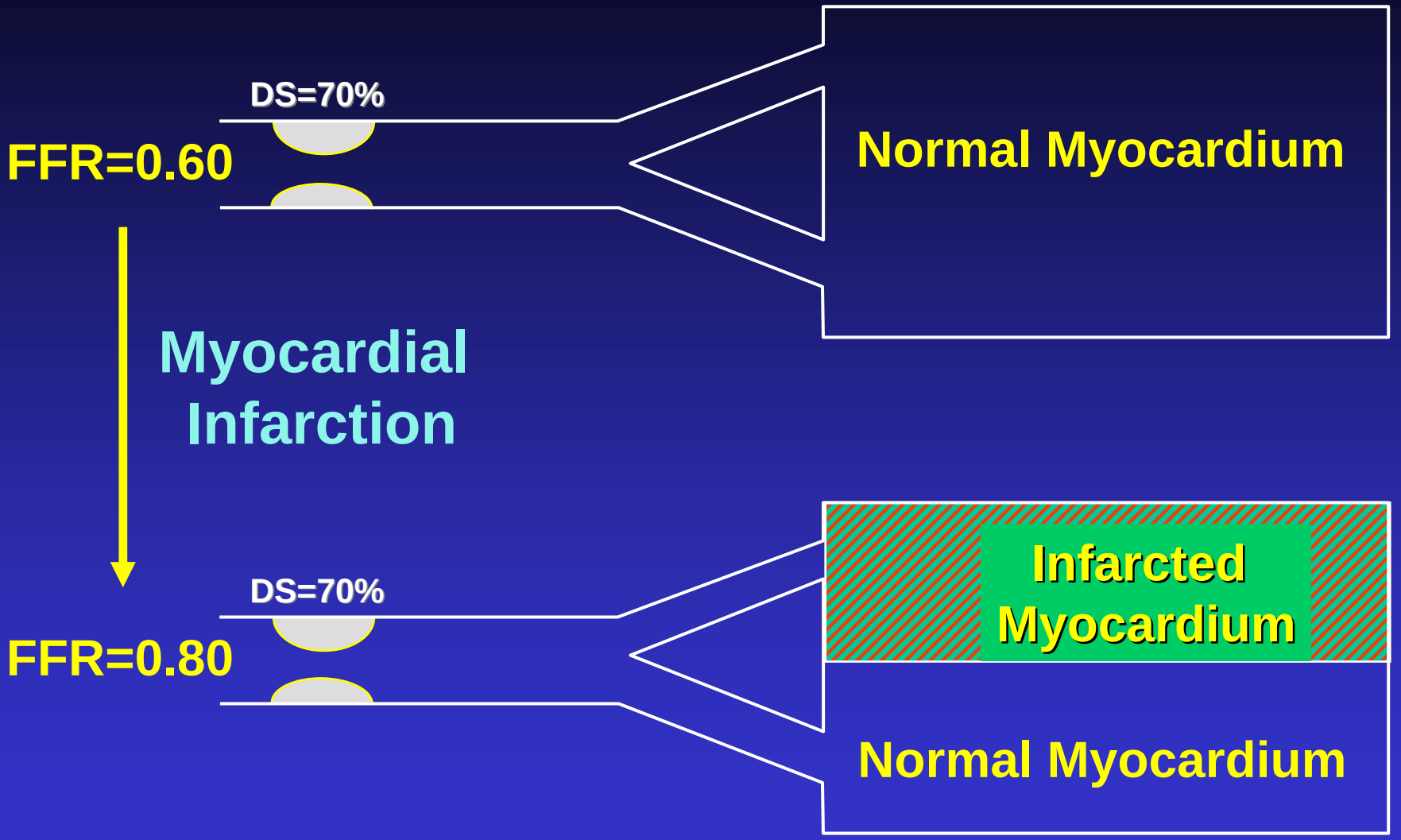
(Yamamuro A, AkasakaT, et al. Circulation 100;144, 1999)

Relationship between Qc / Qn & LVWM recovery

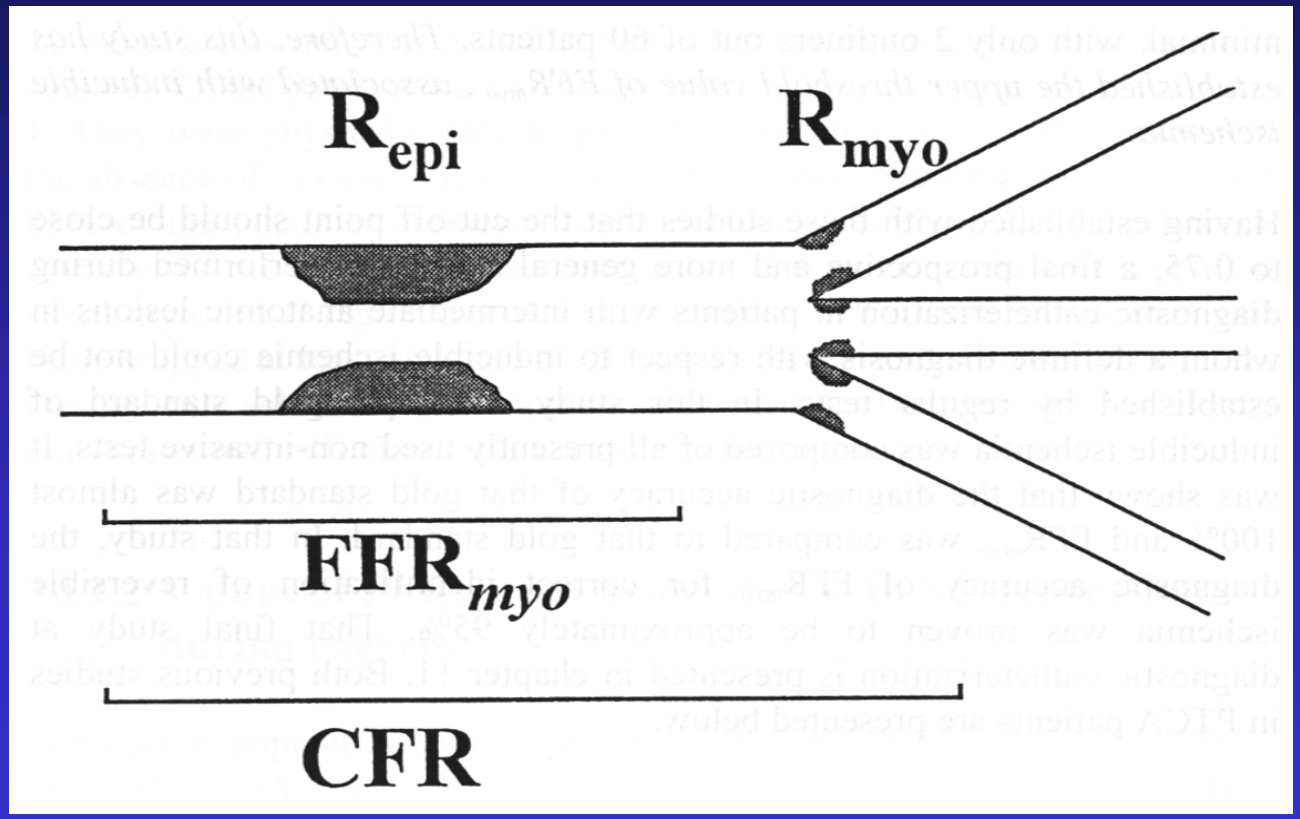


(Lee CW, et al. J Am Coll Cardiol 2000;35:949-955)

FFR & acute myocardial infarction



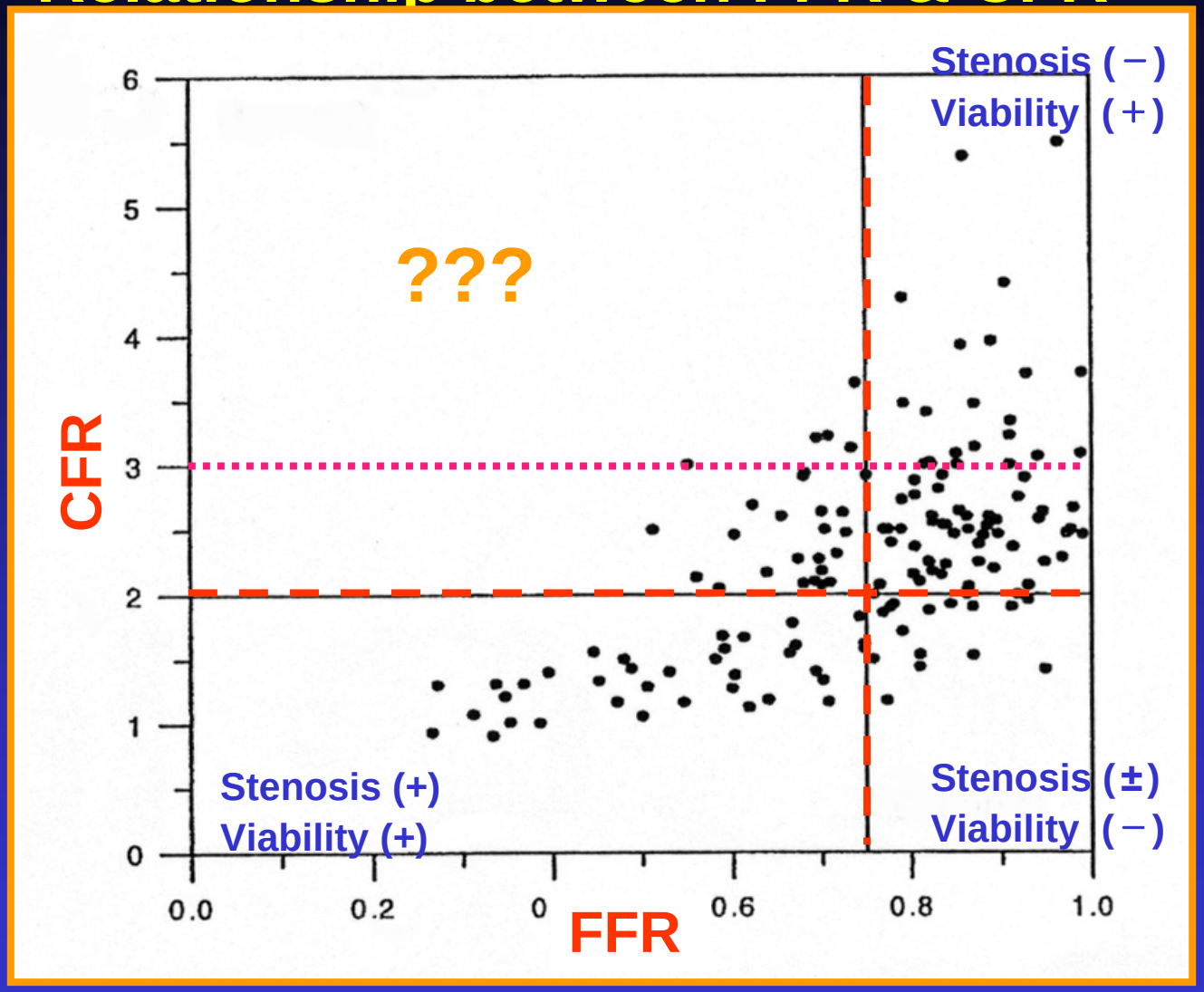
Difference between CFR & FFR



%DS

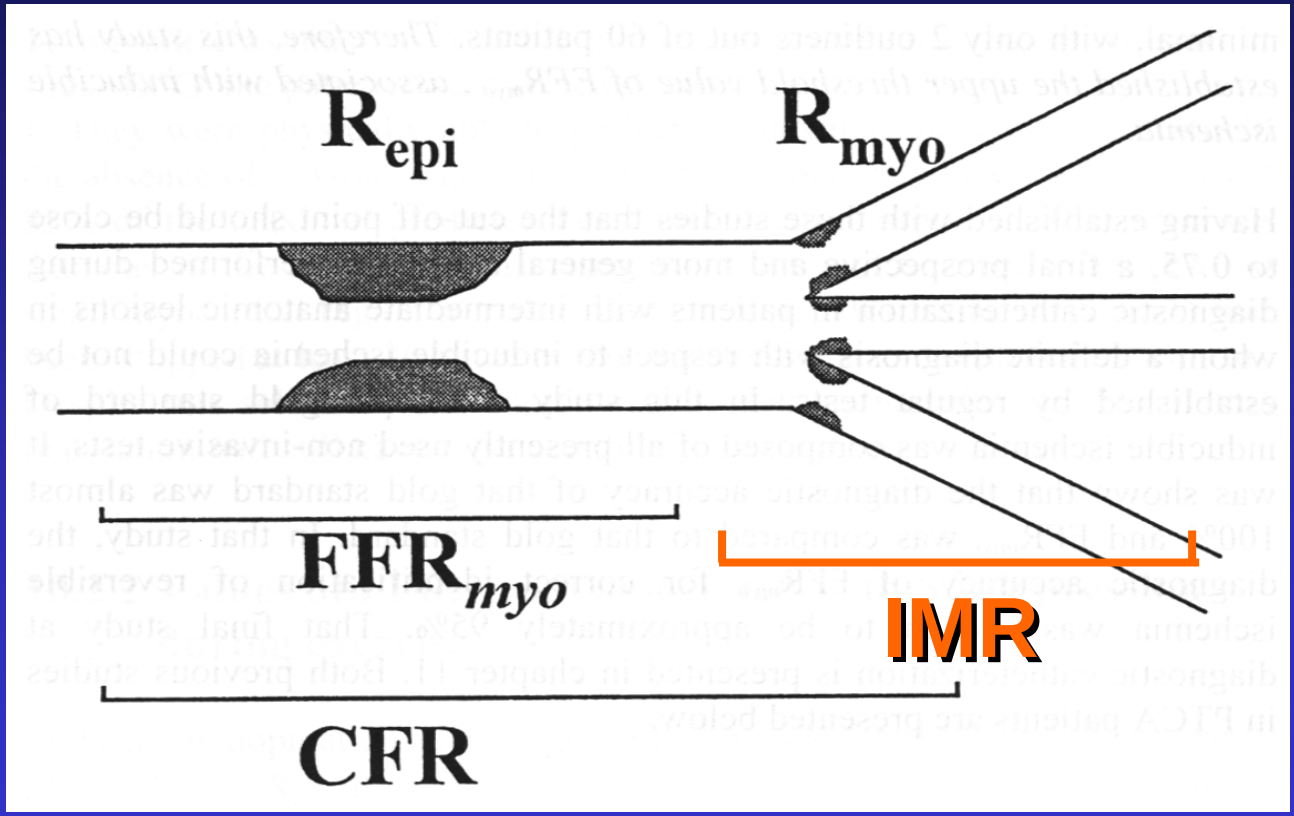
Microvascular disease

Relationship between FFR & CFR

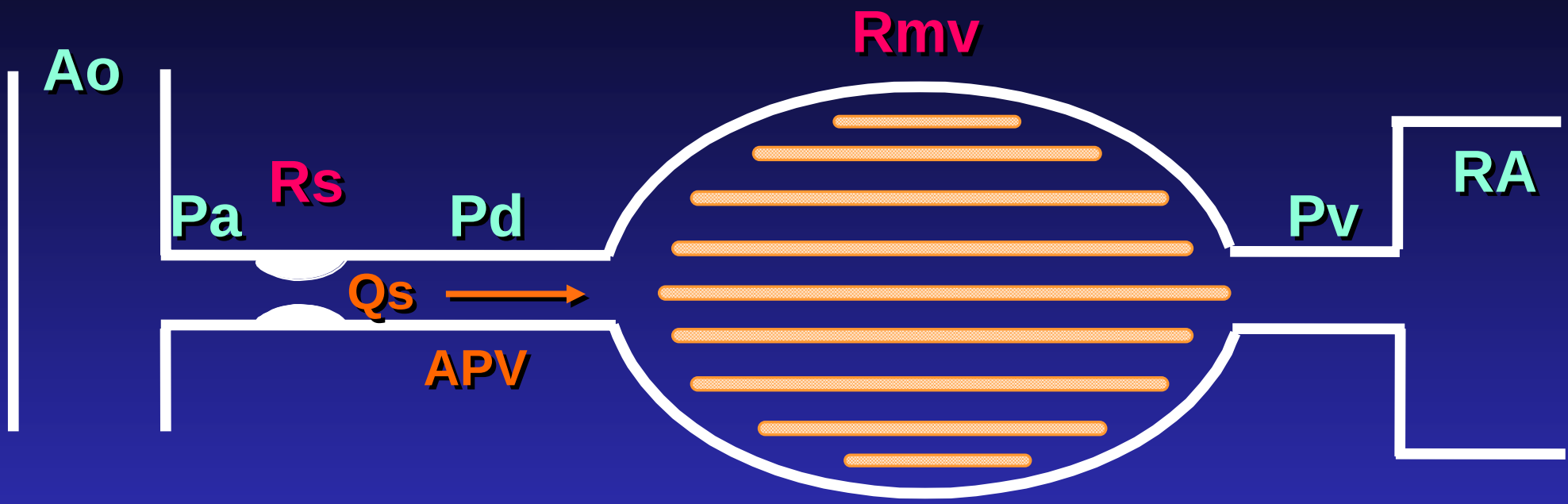


(Meuwissen M, et al. Circulation 103:184 -187, 2001)

Concept of CFR, FFR & IMR



Concept of hyperemic microvascular resistance



Qs: coronary flow through the stenosis

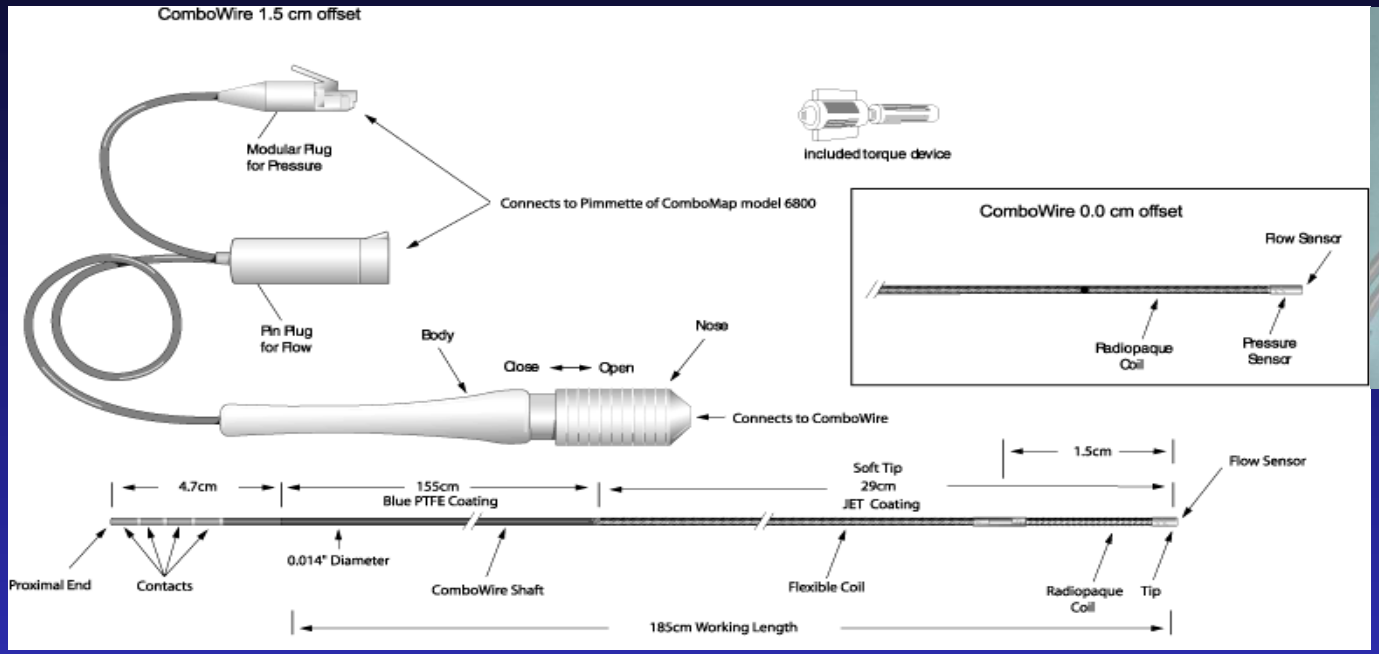
APV : time-averaged peak velocity

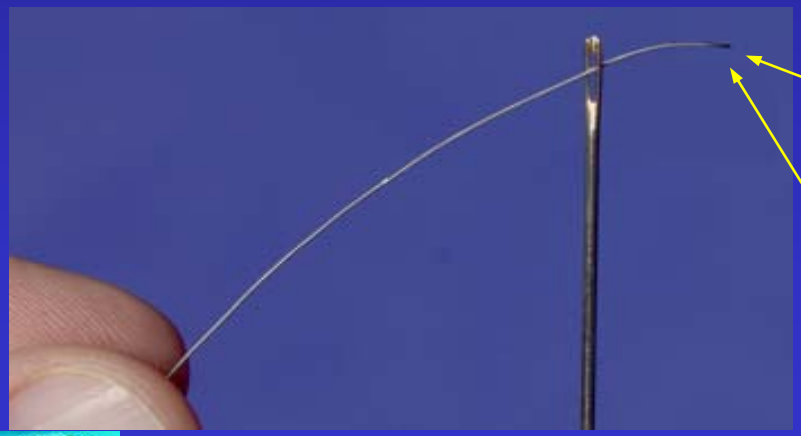
h-Rmv : hyperemic microvascular resistance = (Pd – Pv) HE / Qs HE

h-MRv : hyperemic microvascular resistance index = (Pd – Pv) HE / APV HE

IMR : index of microcirculatory resistance = Pa · Tmn · [(Pd– Pw) / (Pa– Pw)]

Volcano ComboWire®



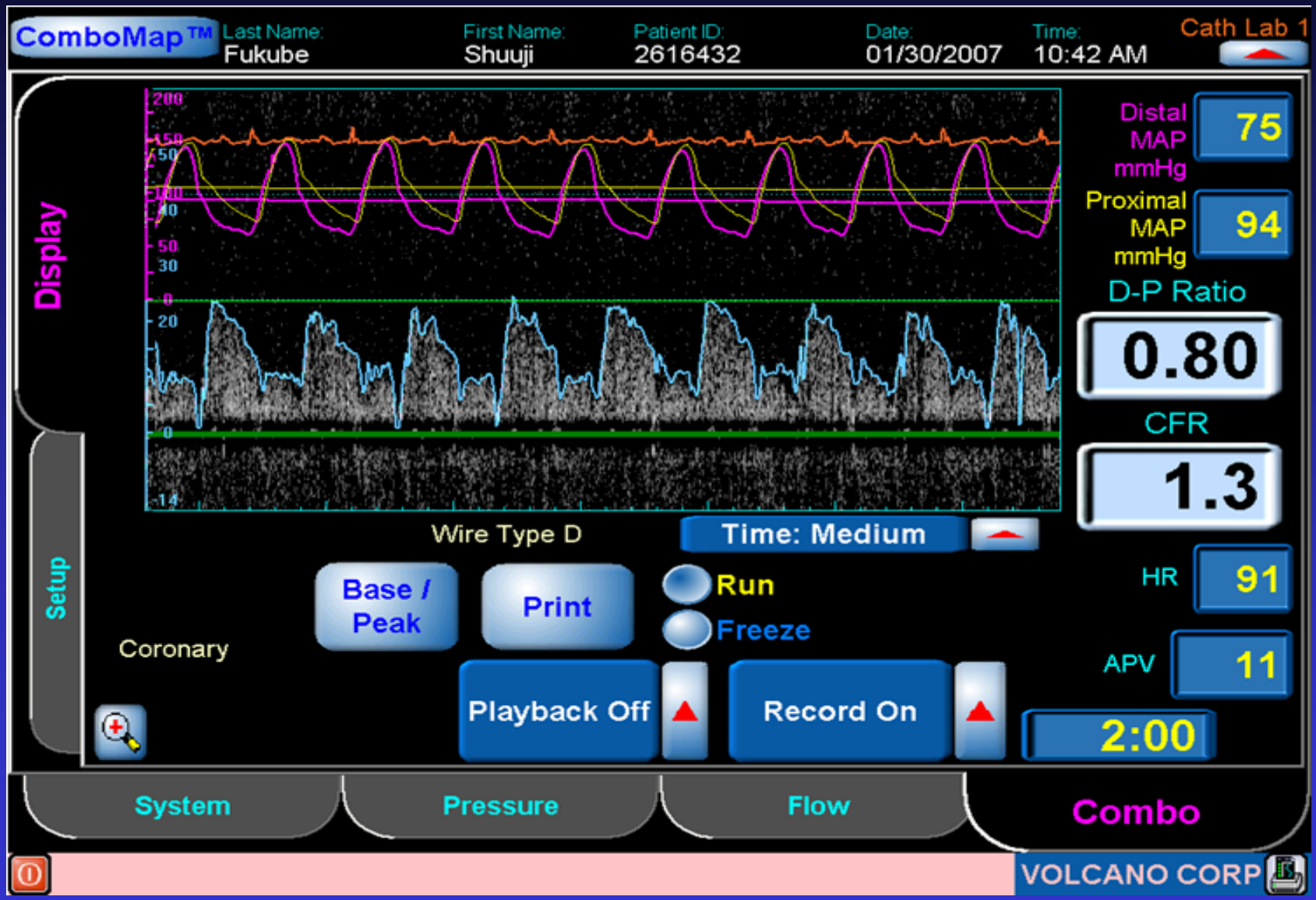


Doppler Velocity Transducer

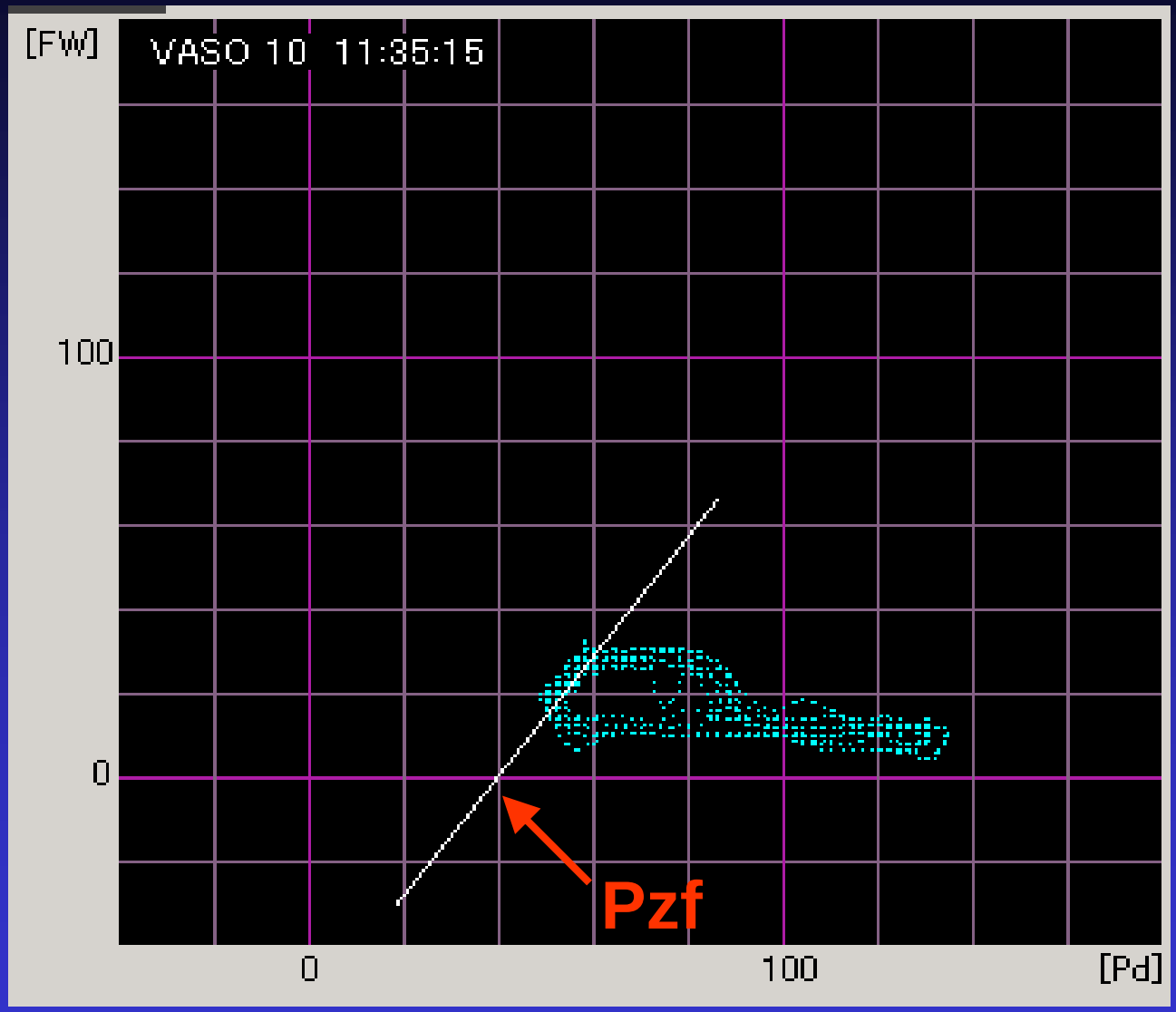
Pressure Sensor

A dual-sensor (pressure and Doppler velocity) guidewire has an ability to estimate coronary microvascular resistance (MVR).

CFR & FFR


ComboMap™
Last Name: Fukube
First Name: Shuuji
Patient ID: 2616432
Date: 01/30/2007
Time: 10:42 AM
Cath Lab 1
Display
Setup
Distal MAP mmHg 75
Proximal MAP mmHg 94
D-P Ratio
0.80
CFR
1.3
Wire Type D
Time: Medium
Base / Peak
Print
Run
Freeze
Coronary
HR 91
APV 11
Playback Off
Record On
2:00
System
Pressure
Flow
Combo
VOLCANO CORP

Pressure-flow loop during hyperemia

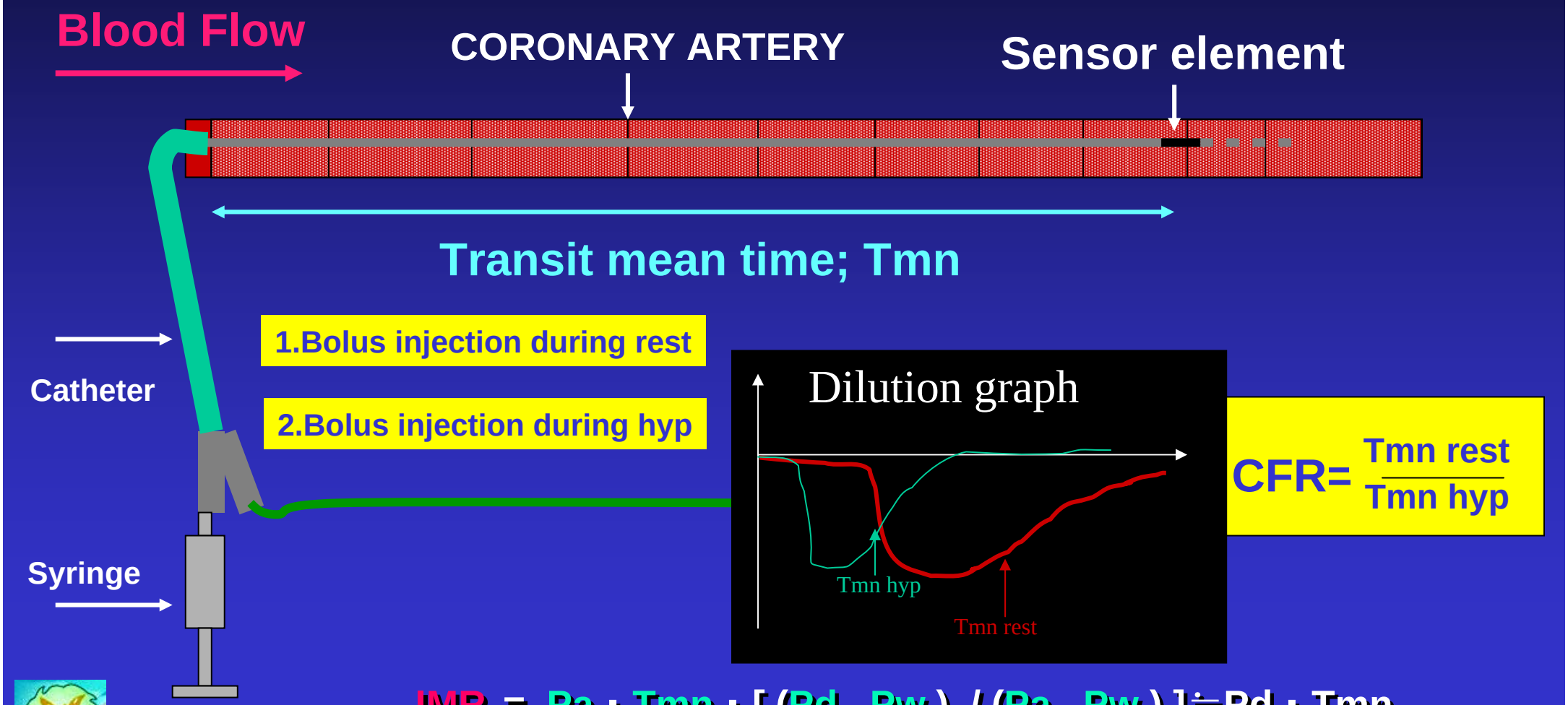


Coronary flow velocity (cm/sec)

Coronary pressure (mmHg)

Simultaneous assessment of FFR & CFR

Operation Principle



$$IMR = Pa \cdot Tmn \cdot [(Pd - Pw) / (Pa - Pw)] \fallingdotseq Pd \cdot Tmn$$

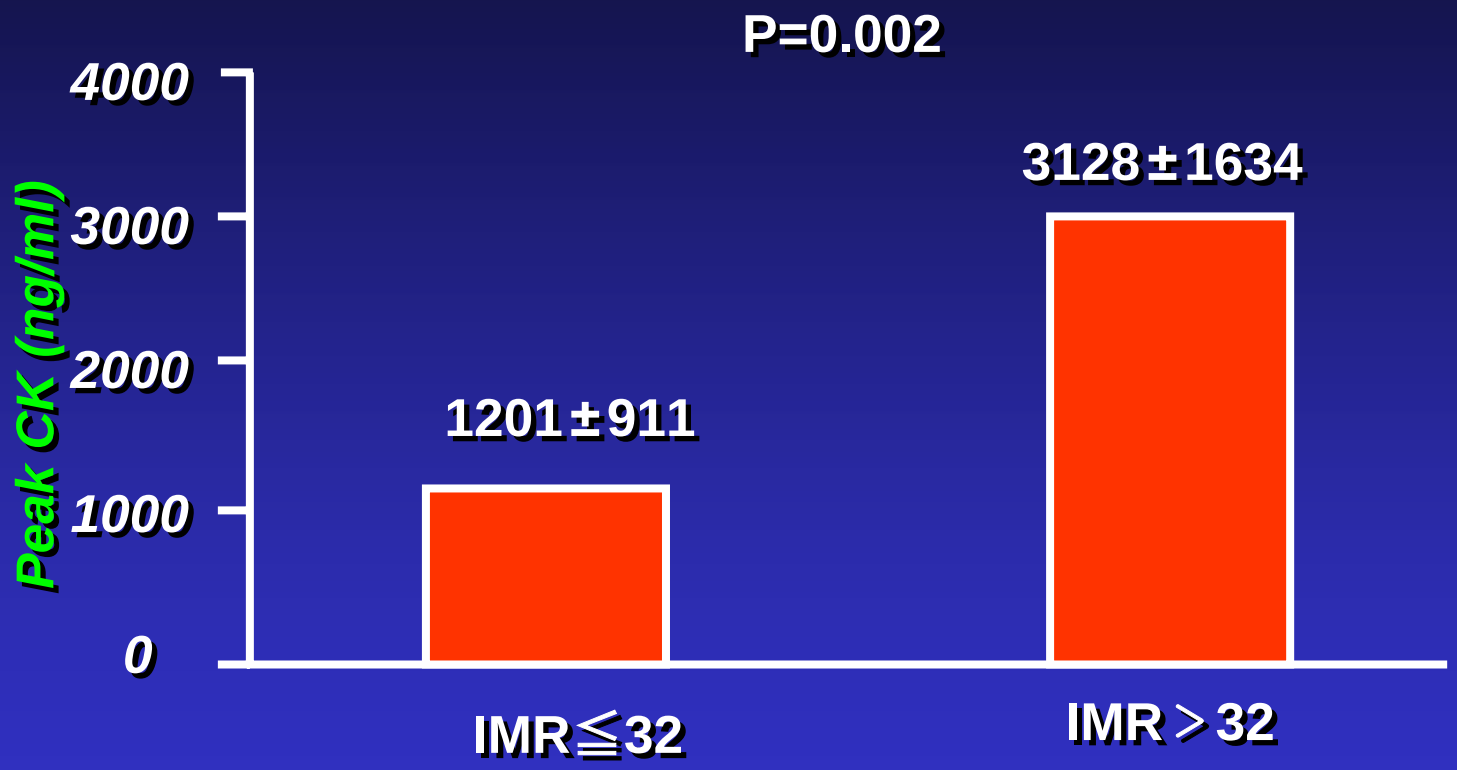
Wakayama Medical University

CFR measurements by thermodilution method

(De Bruyne B, et al. Circulation 104:2003-2006, 2001)

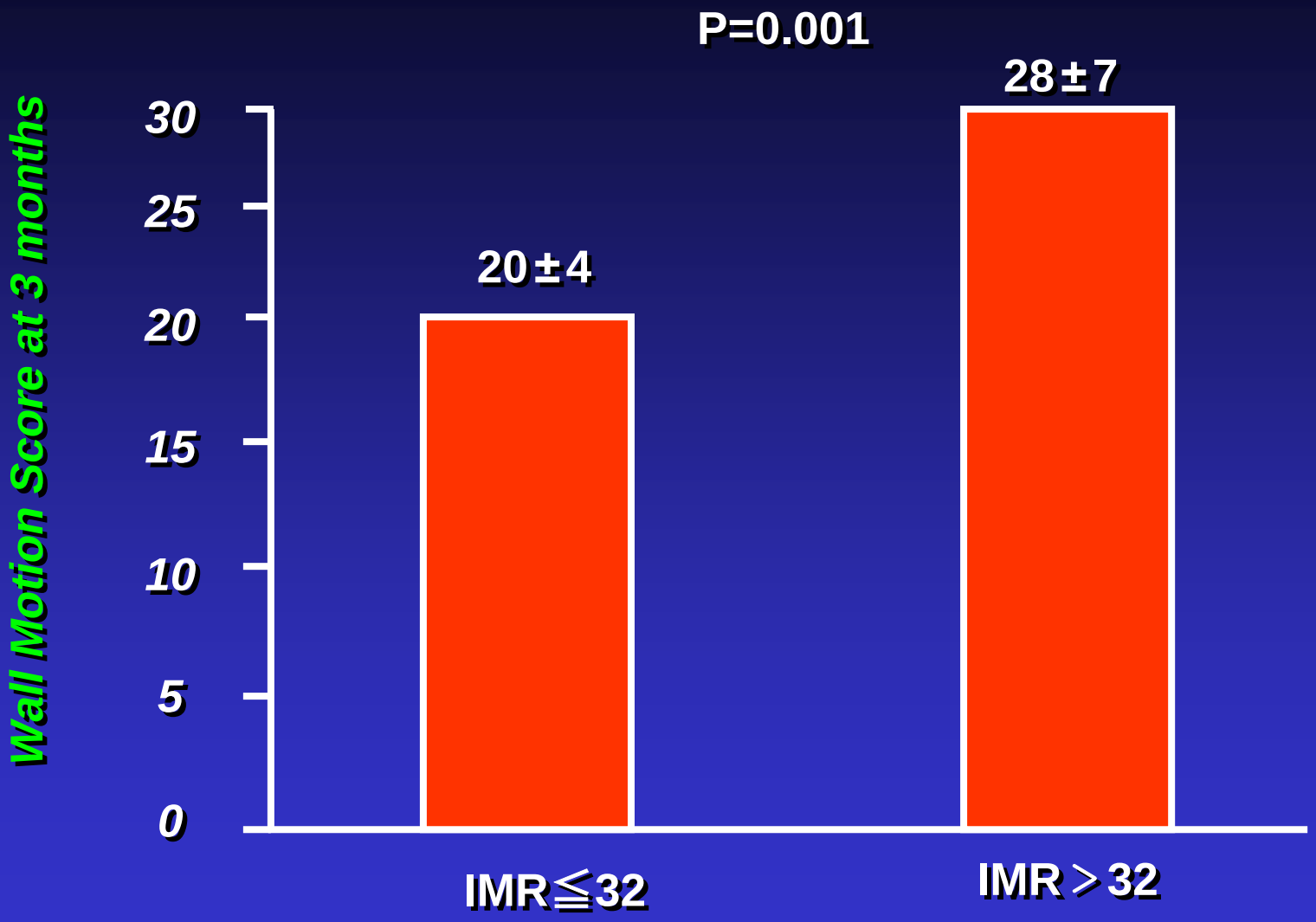
(Pijls NHJ, et al. Circulation 105:2482-2486, 2002)

Peak CK with low and high IMR



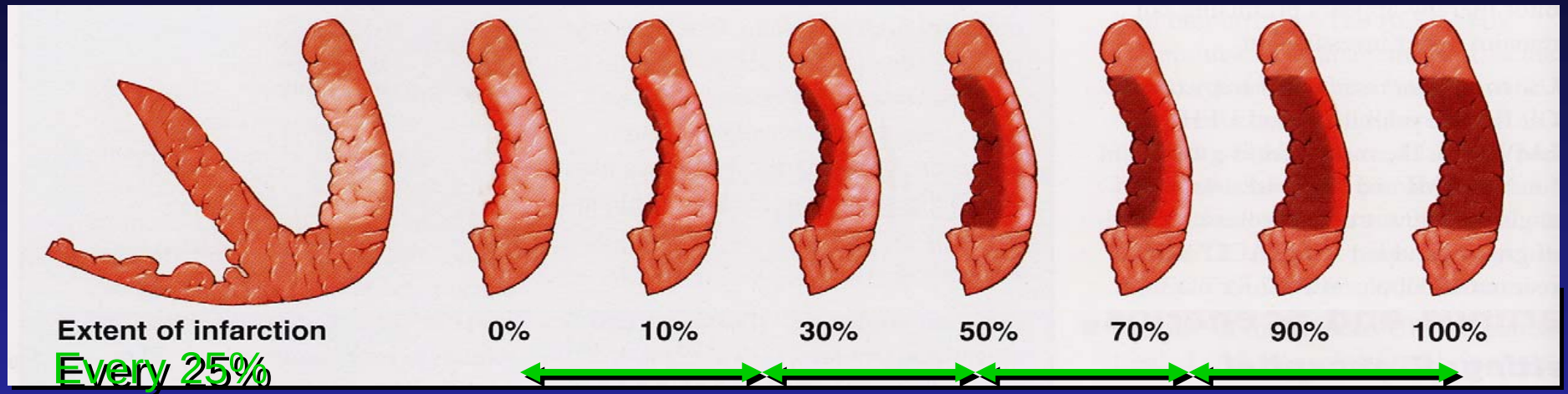
(Fearon WF, et al. J Am Coll Cardiol 51:560-565, 2008)

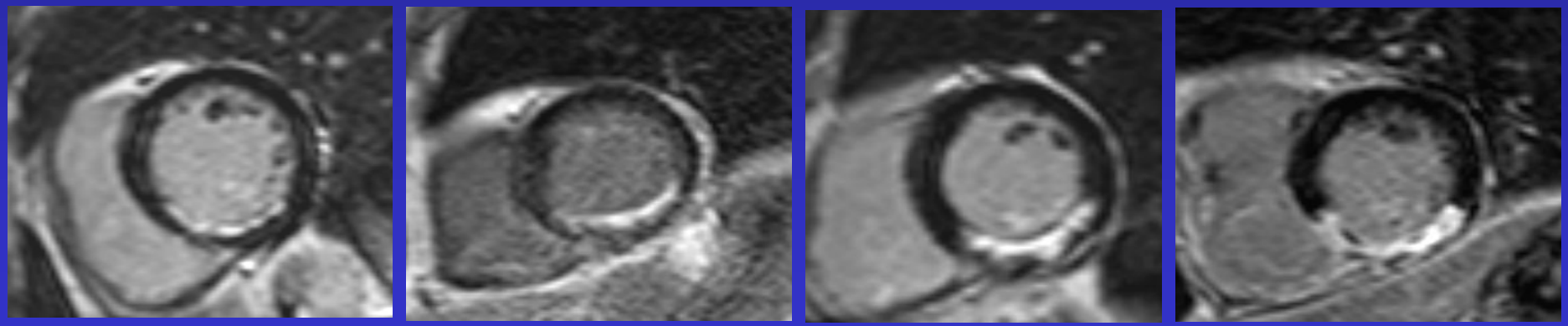
Three-month wall motion score with low and high IMR



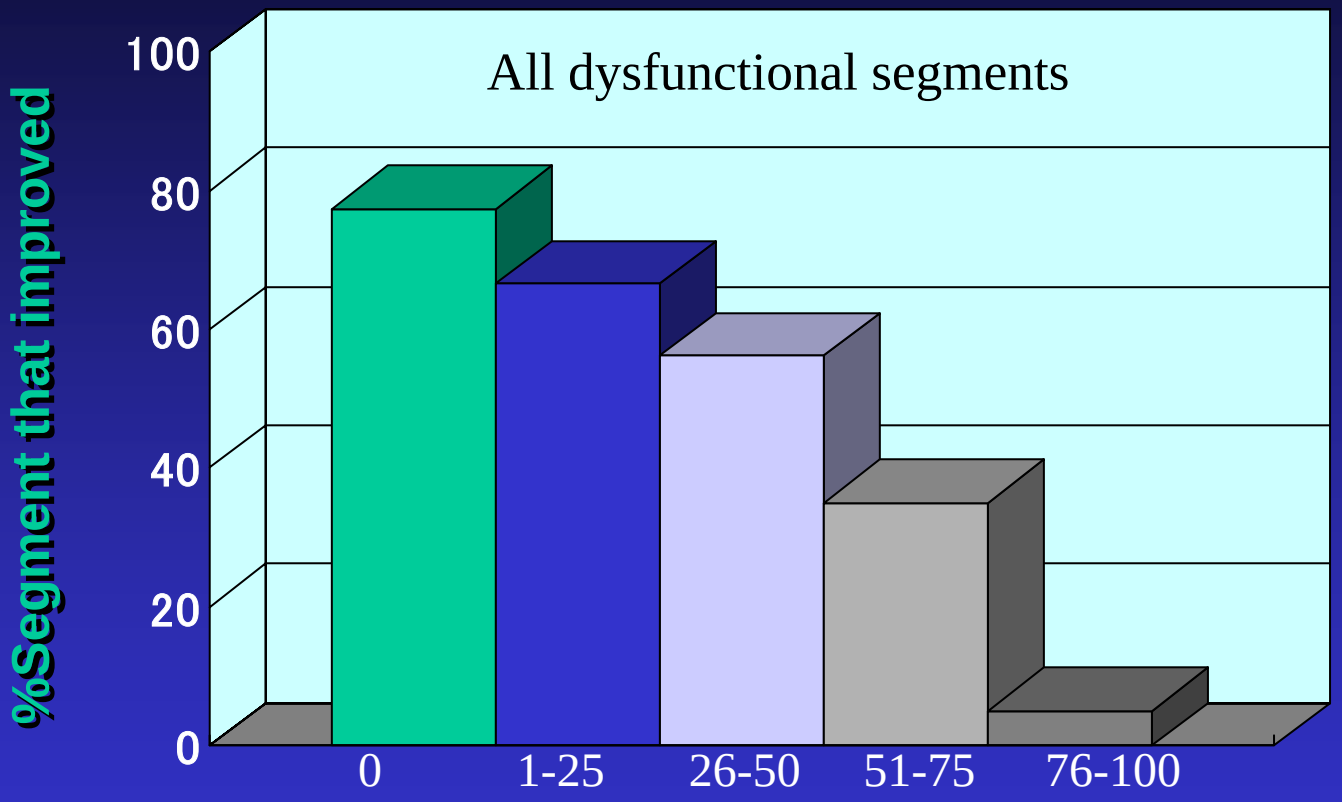
(Fearon WF, et al. J Am Coll Cardiol 51:560-565, 2008)

Transmural Extent of Infarction by delayed enhancement by MRI





Transmural Extent of Acute Myocardial Infarction Predicts Long-Term Improvement in Contractile Function



(Kim RJ, et al; N Eng J Med 2000; 343: 1445-53)

Objective

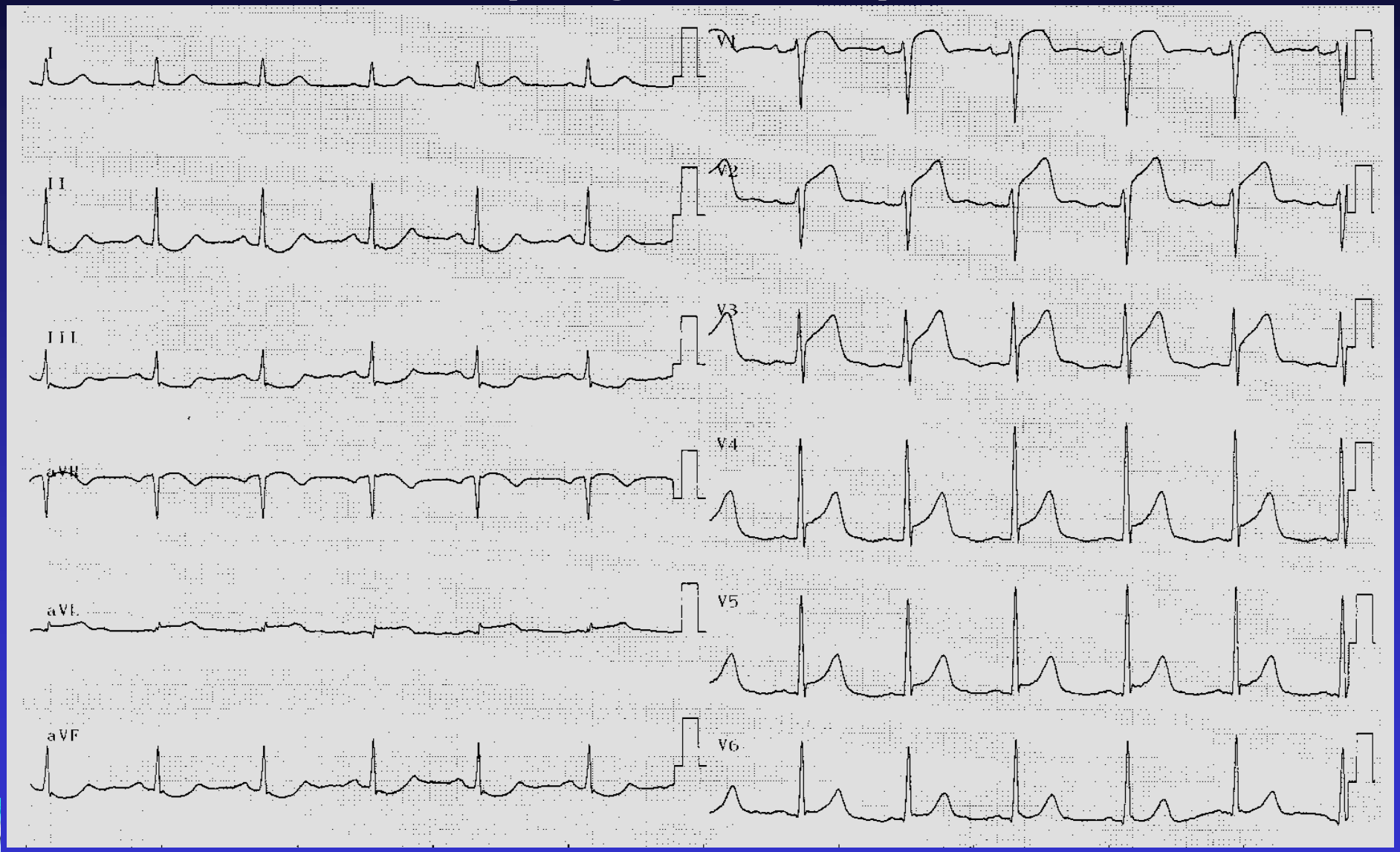
The aim of this study was to assess the relationship between MVR and the transmural extent of infarction (TEI) after primary percutaneous coronary intervention (PCI) in AMI.

Patient characteristics

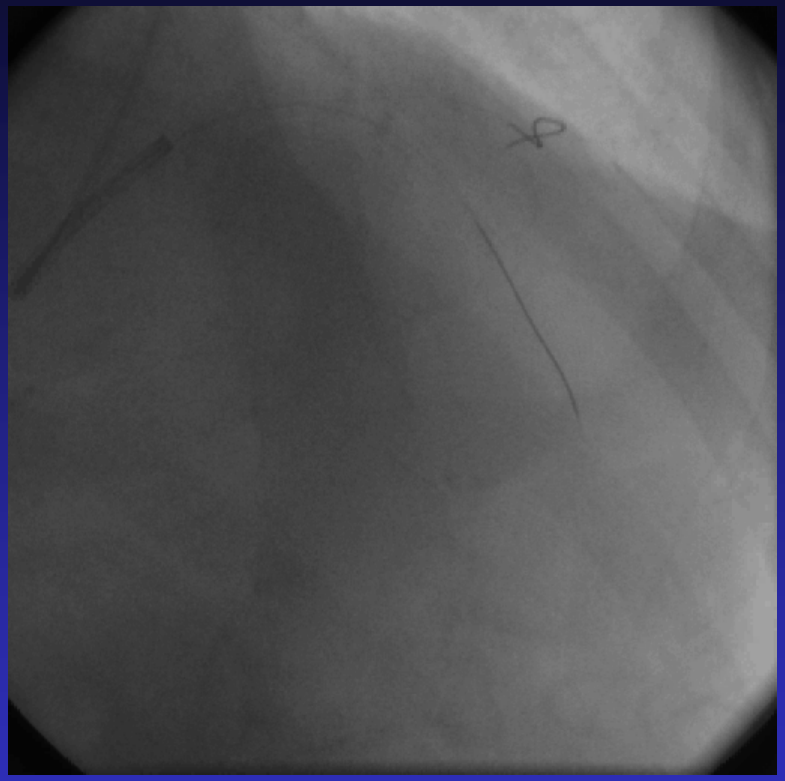
	n=24
Age, years	65 ± 11
Male sex n, (%)	17 (81)
Non-insulin dependent-diabetes mellitus n, (%)	7 (29)
Hypertension n, (%)	14 (58)
Dyslipidemia n, (%)	9 (38)
Current smoking n, (%)	9 (38)
Family history of coronary aretry disease n, (%)	12 (57)
Culprit vessel	
LAD	24 (100)
Time to the evaluation of coronary microcirculation (hour)	4.96 ±2.1

ECG at the time of admission

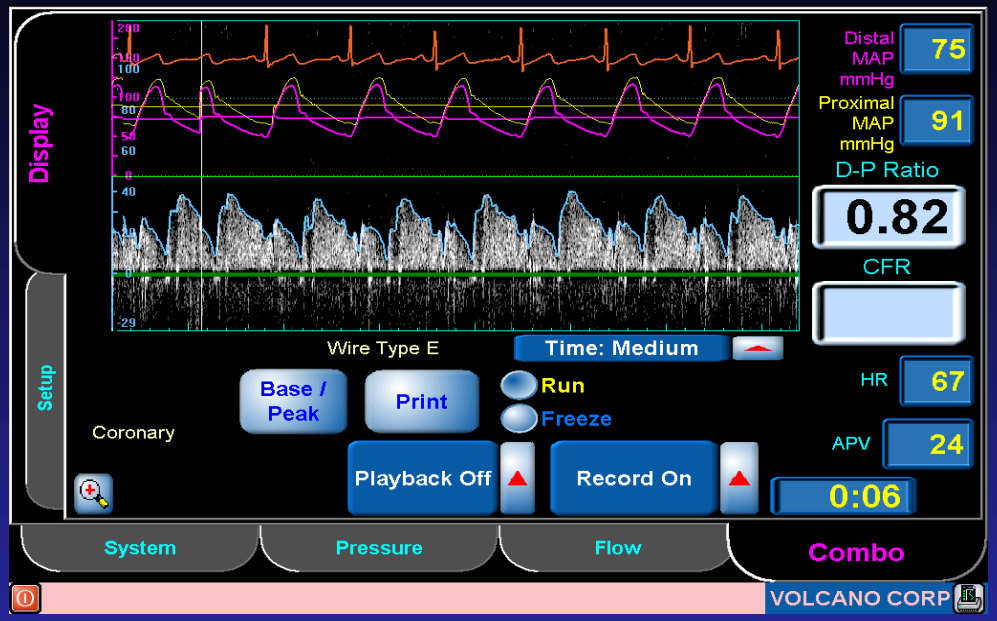
(70 y.o., male)



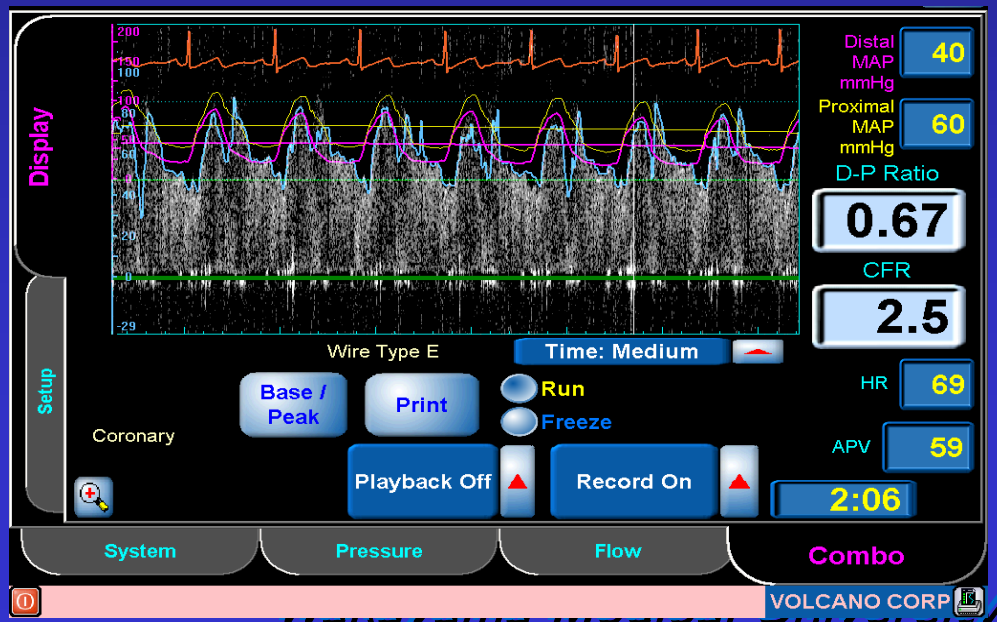
Combowire



Baseline



Hyperemia

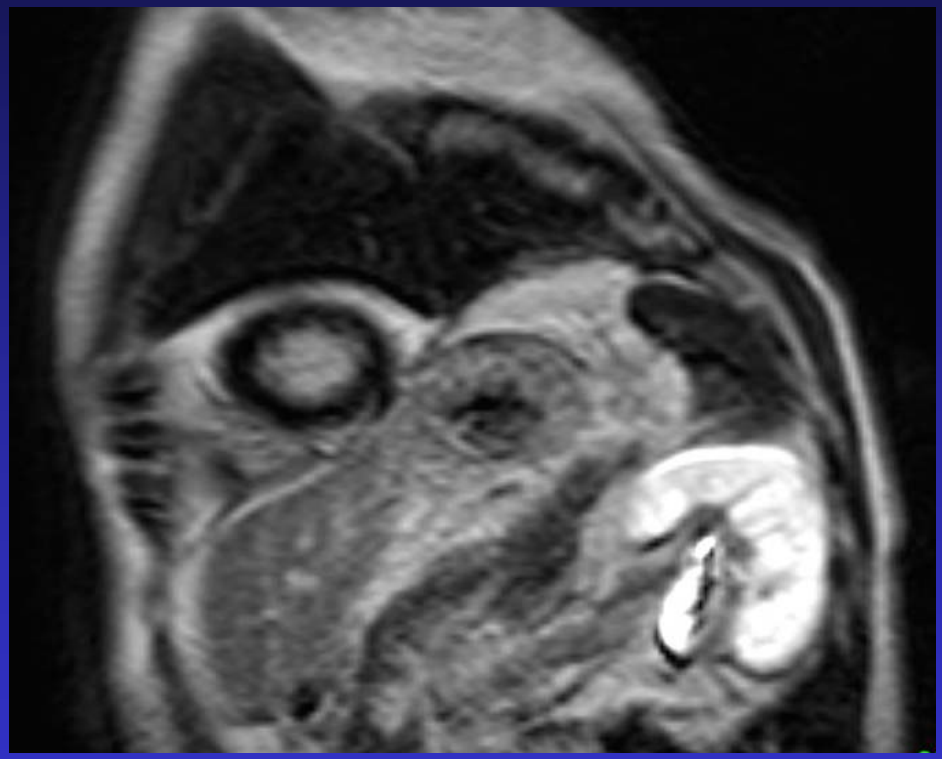


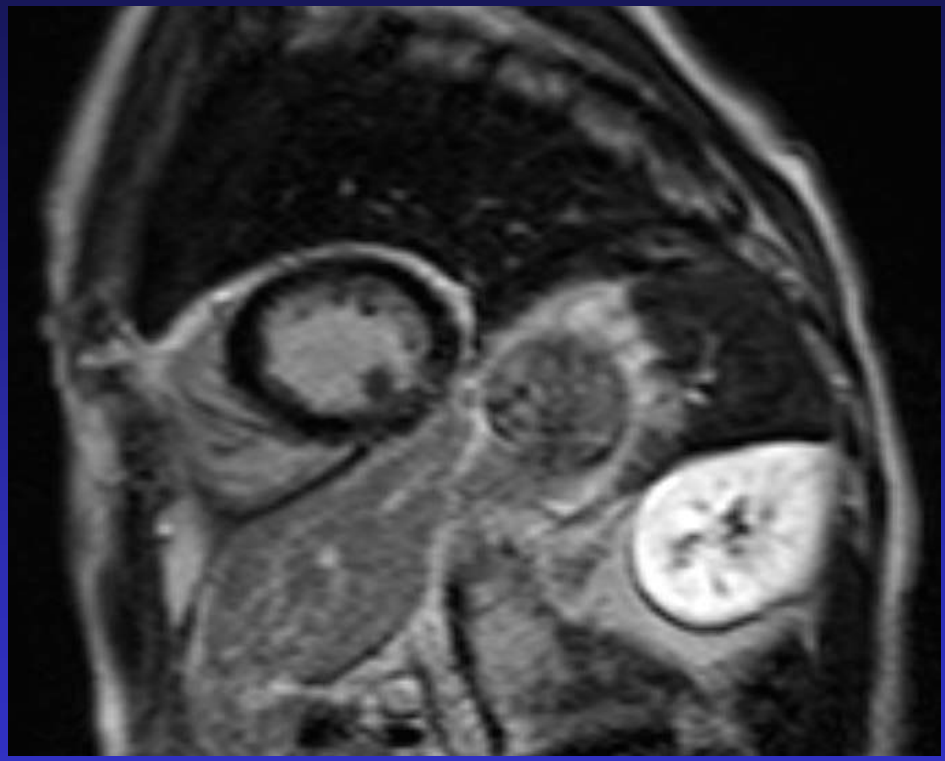
h-MVr = h-Pd / h-APV

= 40 / 59

= 0.68 (mmHg/cm · sec^{-1})

Contrast-enhanced MRI (two weeks after primary PCI)

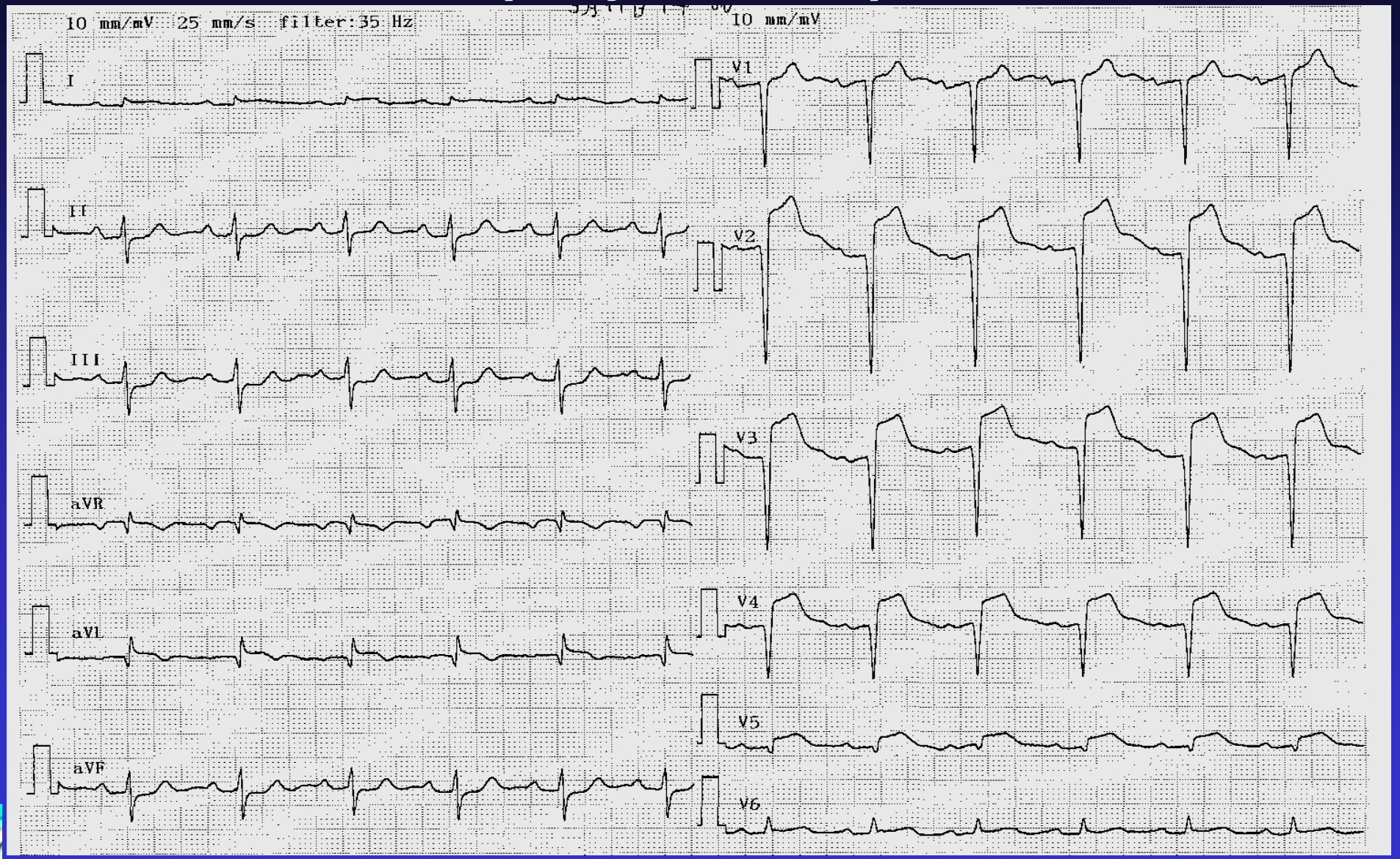




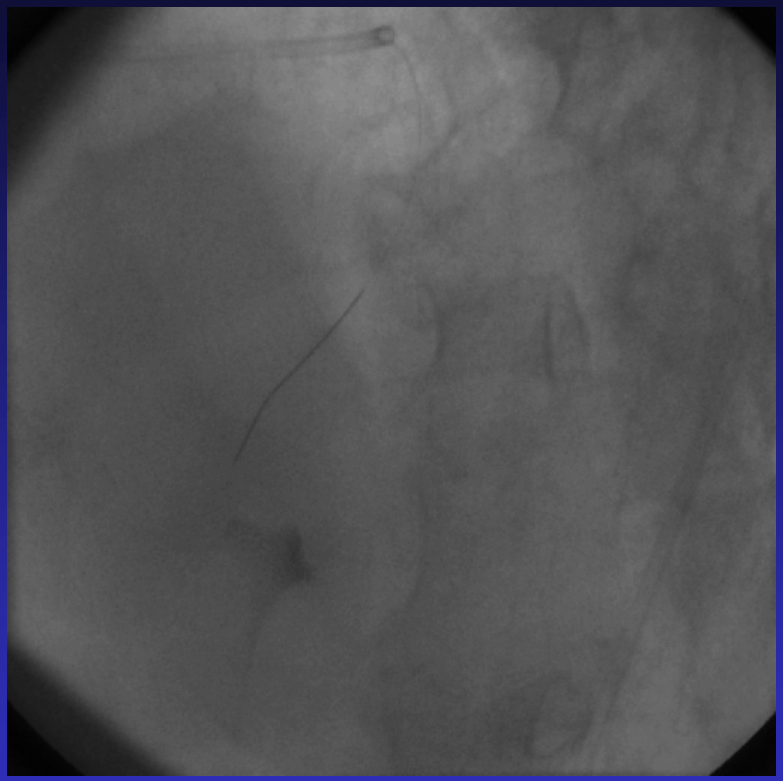
Transmural extent of hyperenhancement Grade 0, peak CK 185 → avoted MI

ECG at the time of admission

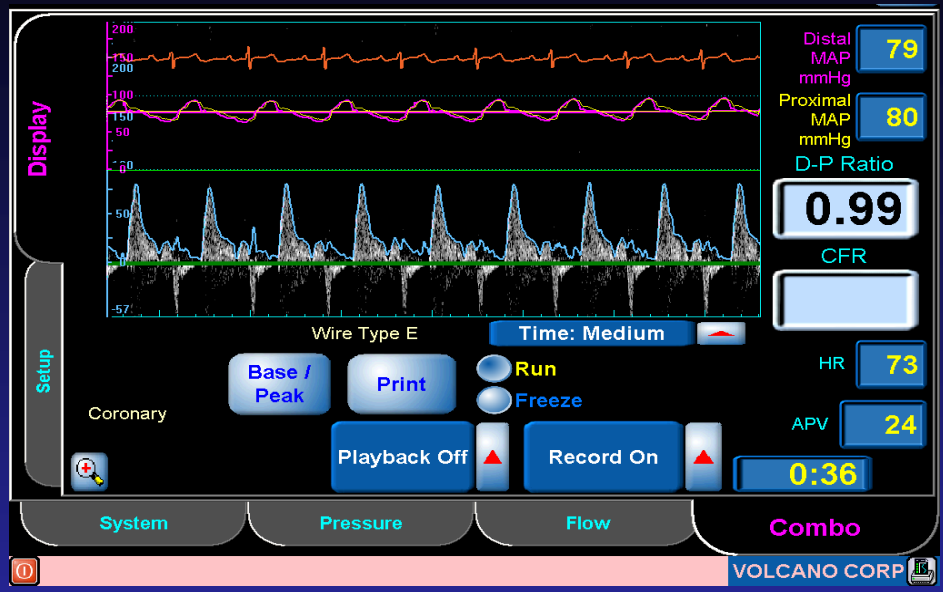
(64 y.o., male)



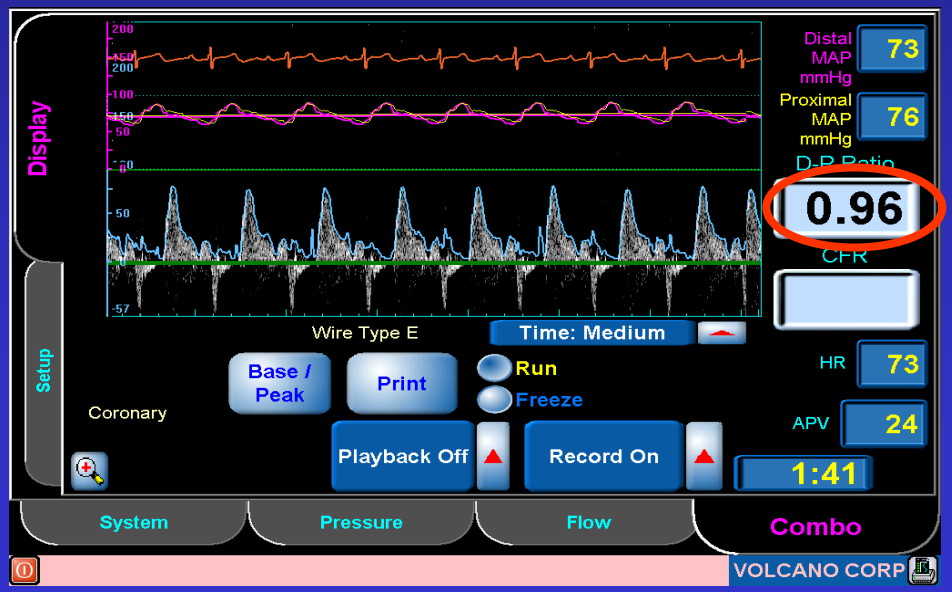
Combowire



Baseline



Hyperemia



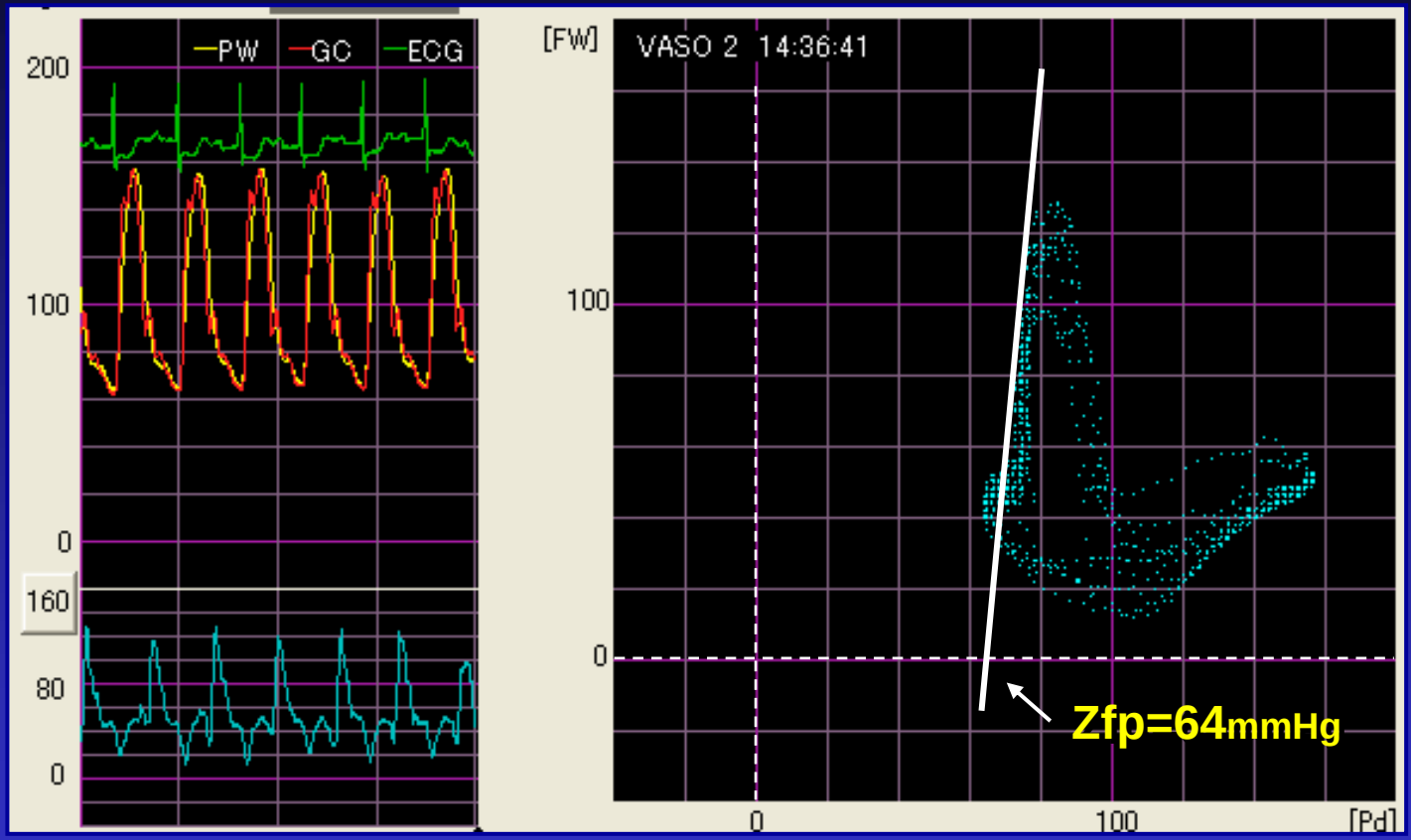
h-MVr = h-Pd / h-APV

= 73 / 24

= 3.04 (mmHg/cm・sec^{-1})

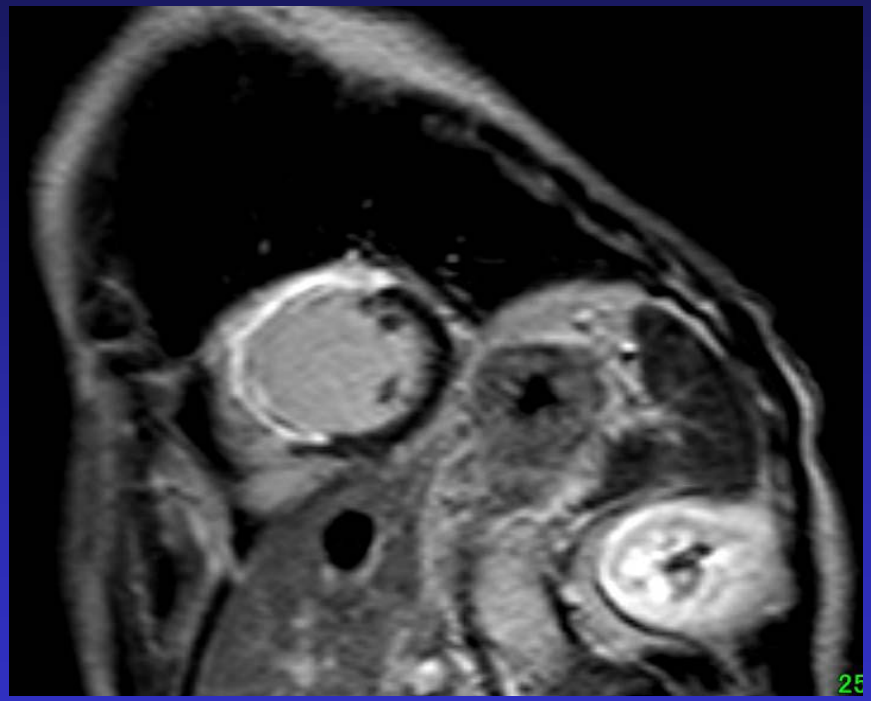
Wakayama Medical University

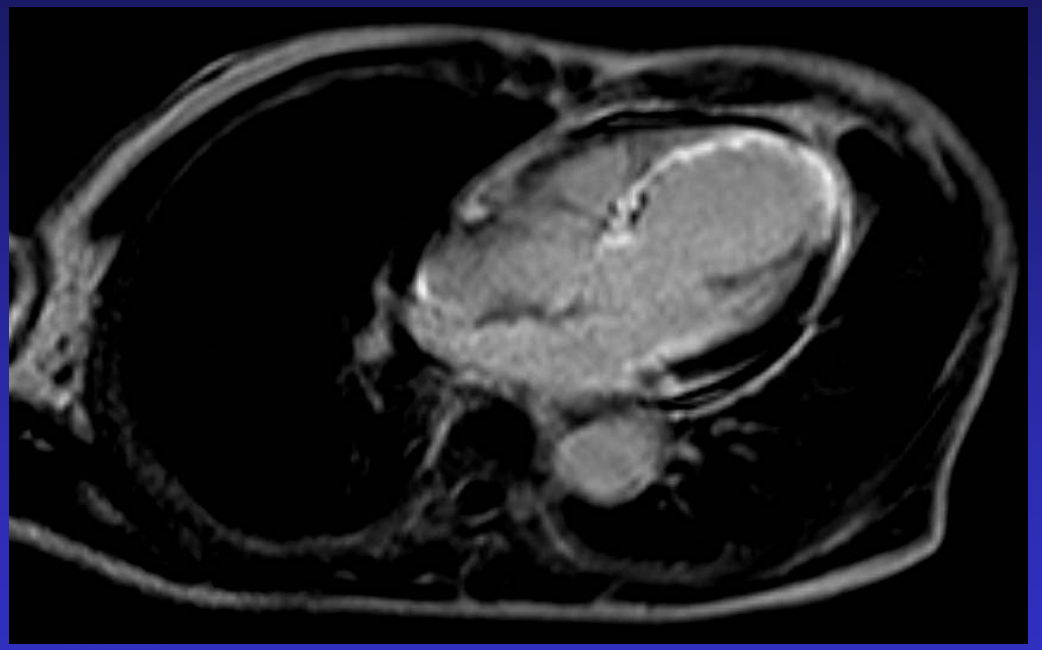
Pressure-flow loop



Coronary microvascular resistance estimated by a novel dual-sensor (pressure and Doppler velocity) guidewire reflects myocardial viability after myocardial infarction

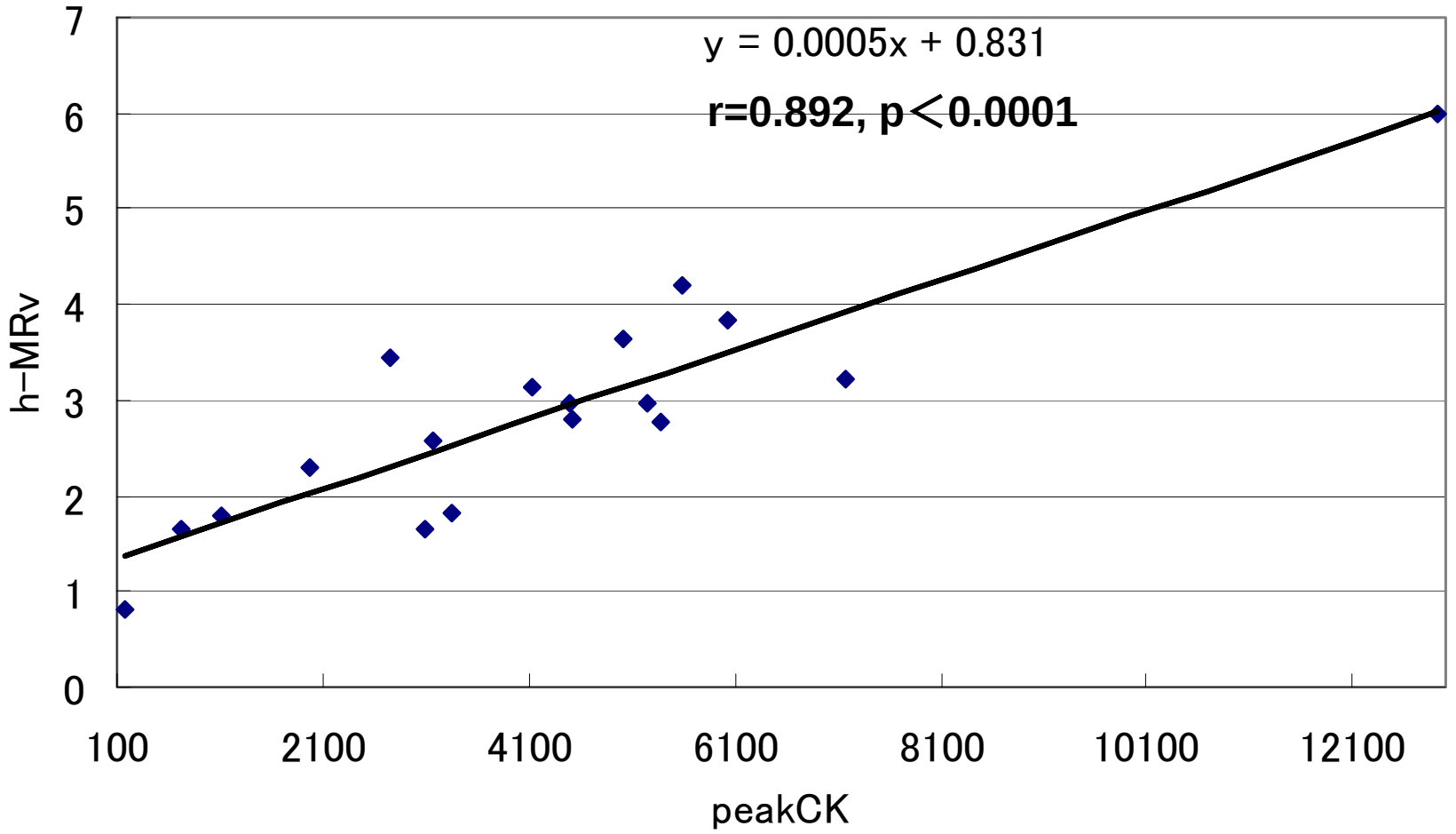
Contrast-enhanced MRI (two weeks after primary PCI)





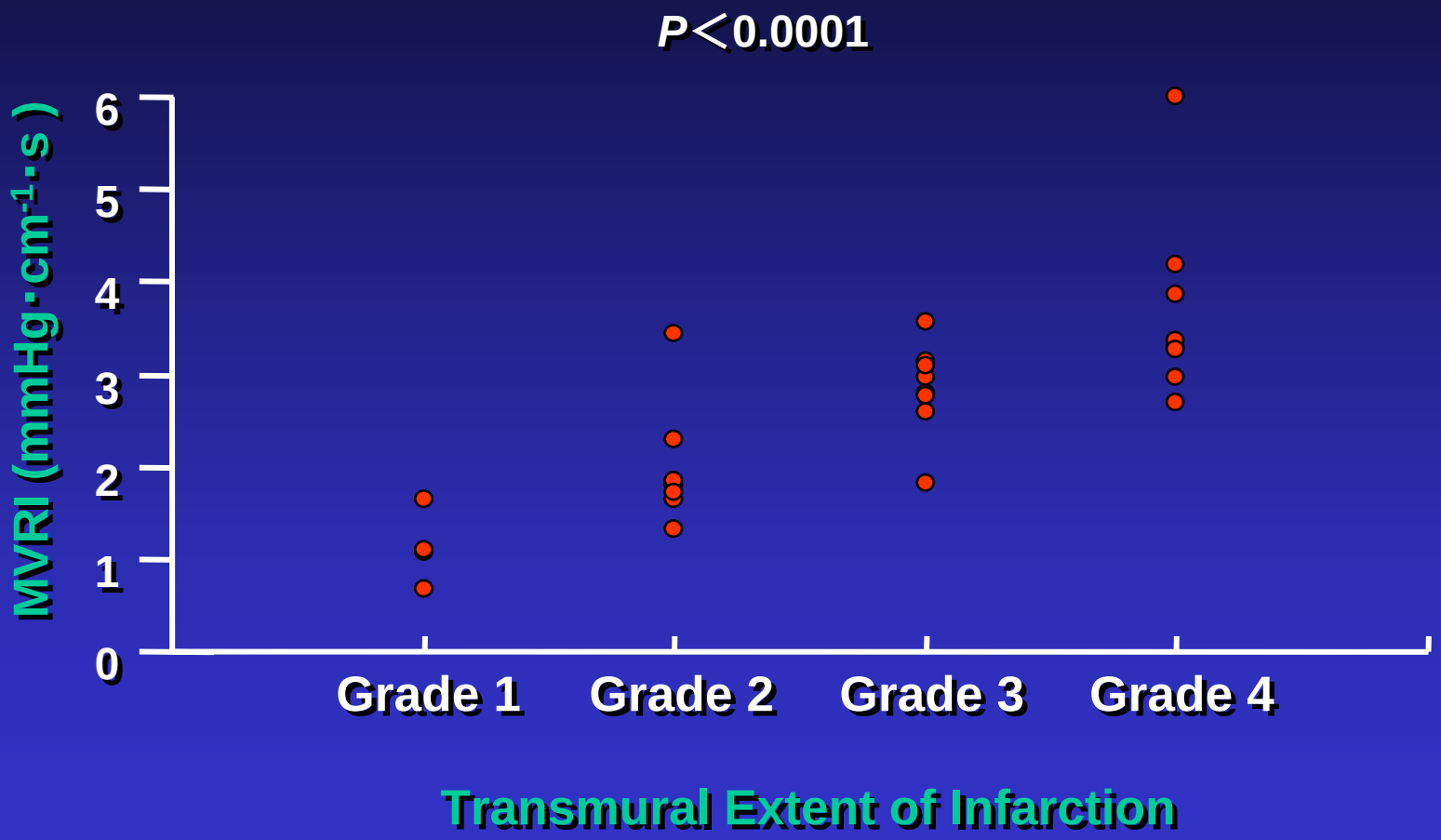
Transmural extent of hyperenhancement Grade 4, peak CK 7182 → transmural MI

Relationship between hyperemic microvascular resistance index and peak CK



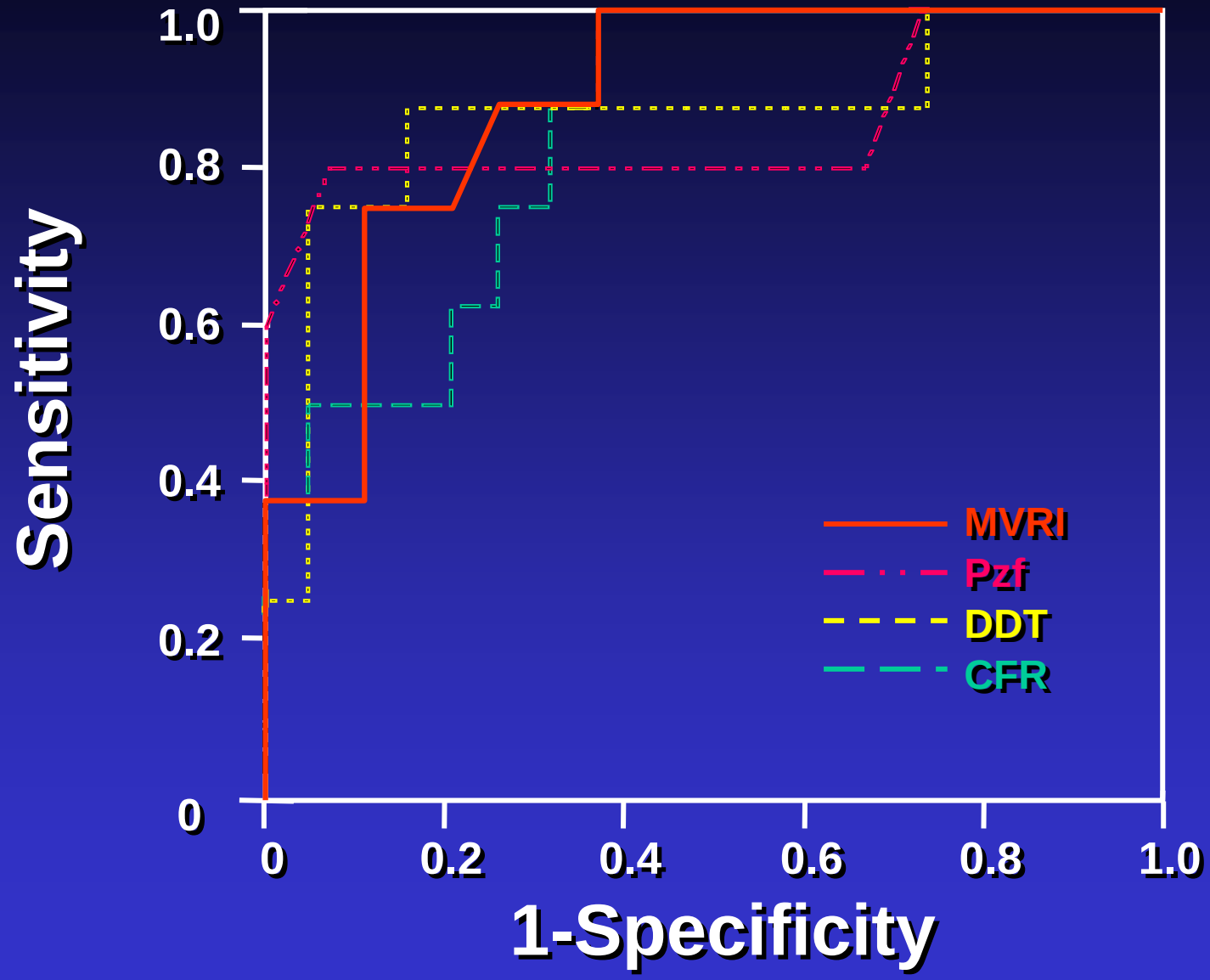
(Kitabata H, et al; J Am Coll Cardiol Imag. 2009, 2: in press)

Relationship between hyperemic microvascular resistance and transmural extent of MI by de-MRI



(Kitabata H, et al; J Am Coll Cardiol Imag. 2009, 2: in press)

ROC curve in each index



(Kitabata H, et al; J Am Coll Cardiol Imag. 2009, 2: in press)

Summary

1. The condition of coronary microcirculation is an important determinant of myocardial viability and clinical outcomes in AMI.

2. There would be some indexes to speculate micro-circulation condition such as CFR, DDT, Pzf and microvascular resistance index.

3. A 0.014-inch dual-sensor (pressure and Doppler velocity) guidewire (Combowire™) and pressure guidewire with thermodilution may allow us to estimate these indexes at the same time.

Conclusion

Within the indexes to speculate micro-circulation condition such as CFR, DDT, Pzf and microvascular resistance index (MVRI & h-MVr), MVRI & h-MVr might be the best predictor of the LV functional recovery.

Methods(1)

Study population

- 24 patients who underwent primary PCI for the first anterior AMI

within 12 hours from the onset of symptoms

Exclusion criteria

- Left main trunk lesion
- History of prior MI
- Cardiogenic shock
- Renal insufficiency (serum creatinine ＞1.5mg/dl)
- Insulin-dependent diabetes mellitus
- Contraindications to MRI (pacemaker, atrial fibrillation, claustrophobia and so on)

Methods(2)

Primary percutaneous coronary intervention

・Thrombectomy ・Bare metal stent

Hemodynamic measurements and data analysis

・Immediately after PCI, a 0.014-inch dual-sensor guidewire was placed distal to the culprit lesion to take per-beat averages of pressure and flow velocity simultaneously.

・Microvascular resistance index (MVRI) during maximal hyperemia; [Mean distal pressure] / [Average peak flow velocity] (mmHg・cm^{-1}・s)

・ Hyperemic agent; intravenous infusion of adenosine (150 μg / kg / min)

Creatine kinase (CK) and CK-MB fraction measurements

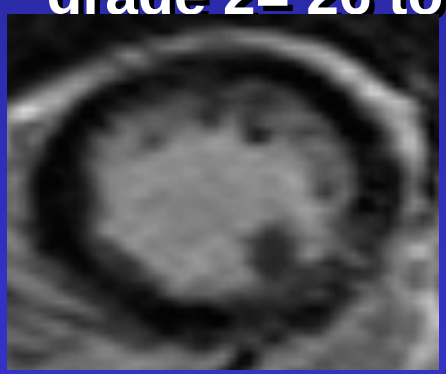
・Before and immediately after primary PCI, and every 3 hours for the

Methods(3)

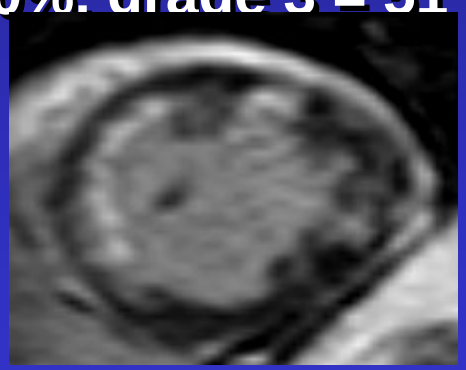
Delayed contrast-enhanced MRI and data analysis

- Two weeks after the onset of AMI
- Gadolinium-diethlenetriamine pentaacetic acid (0.1mmol/kg)
- 1.5-T MR scanner (Gyroscan Intera CV, Philips, the Netherlands)
- Transmural extent of infarction (TEI) by delayed contrast-enhanced MRI;

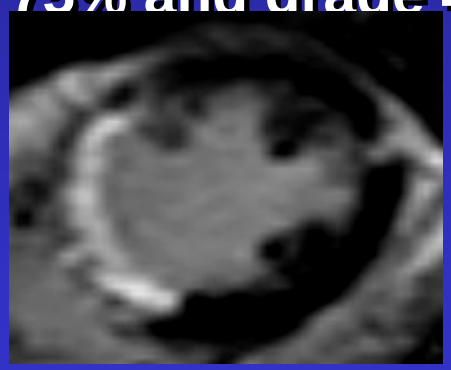
grade 1= 0 to 25% of hyperenhanced extent of left ventricular wall, grade 2= 26 to 50%, grade 3 = 51 to 75% and grade 4 =76 to 100%



grade 1



grade 2



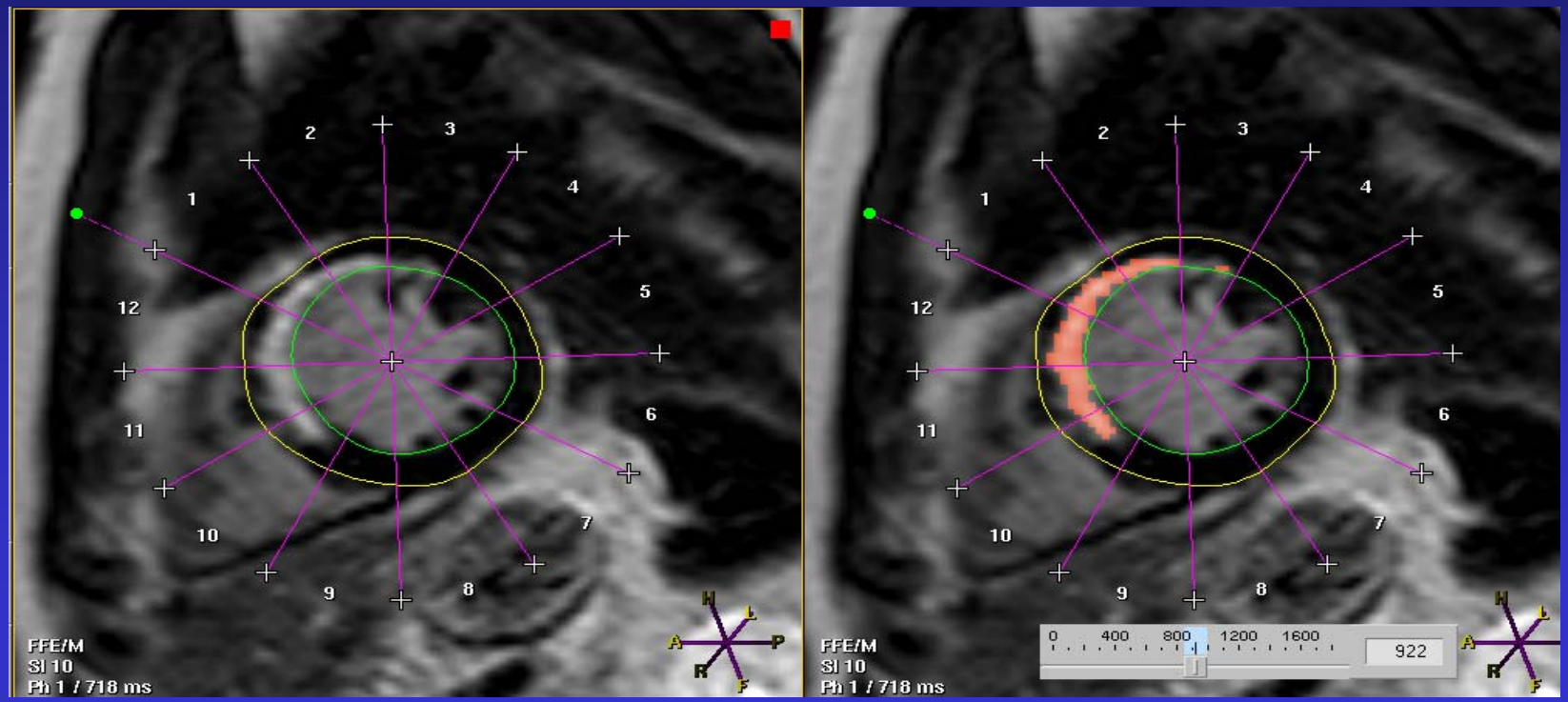
grade 3

grade 4

Methods(4)

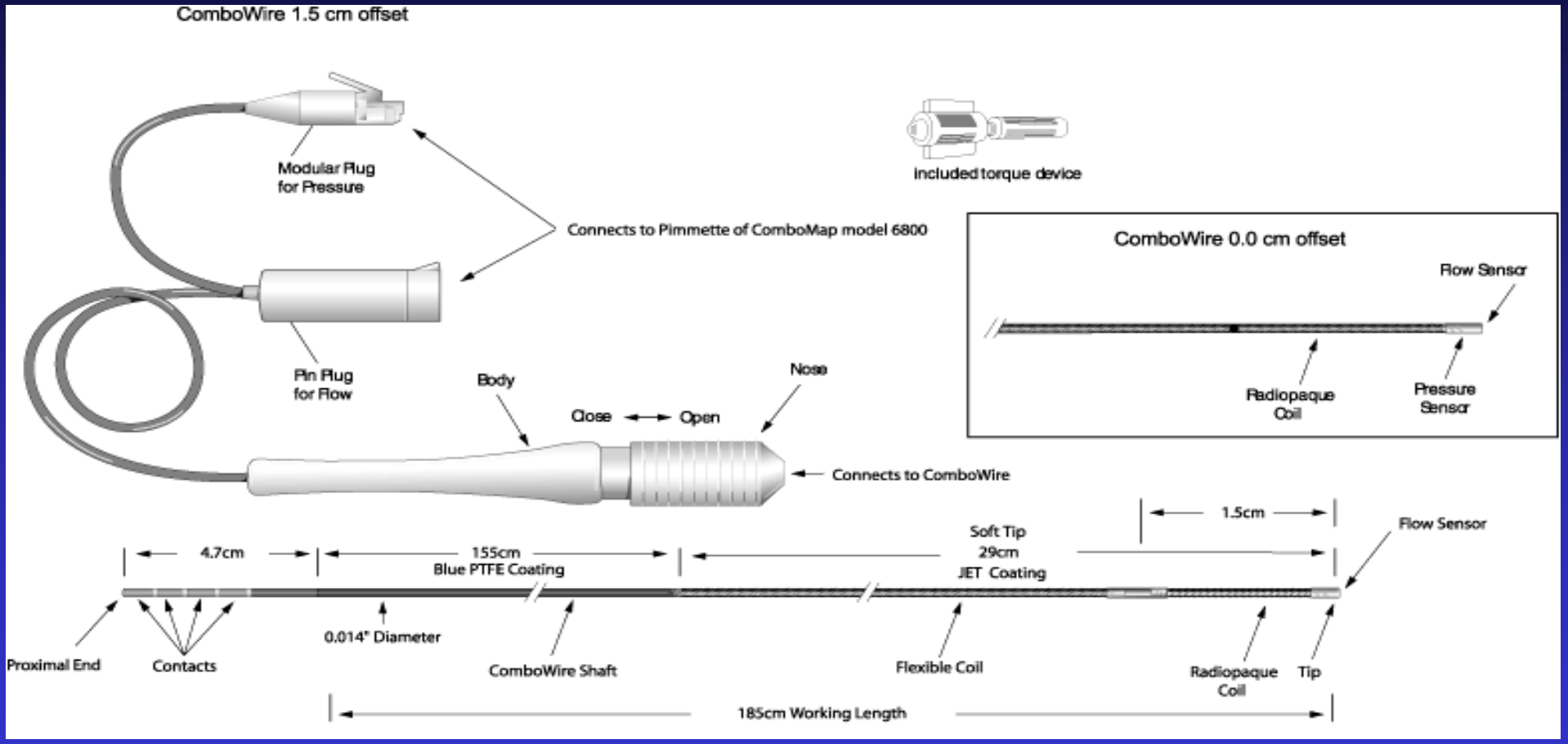
- Infarct size by delayed ce-MRI (%LV);

[Sum of the volume of DE regions for all slices] / [Sum of the LV myocardial cross-sectional volumes] ×100

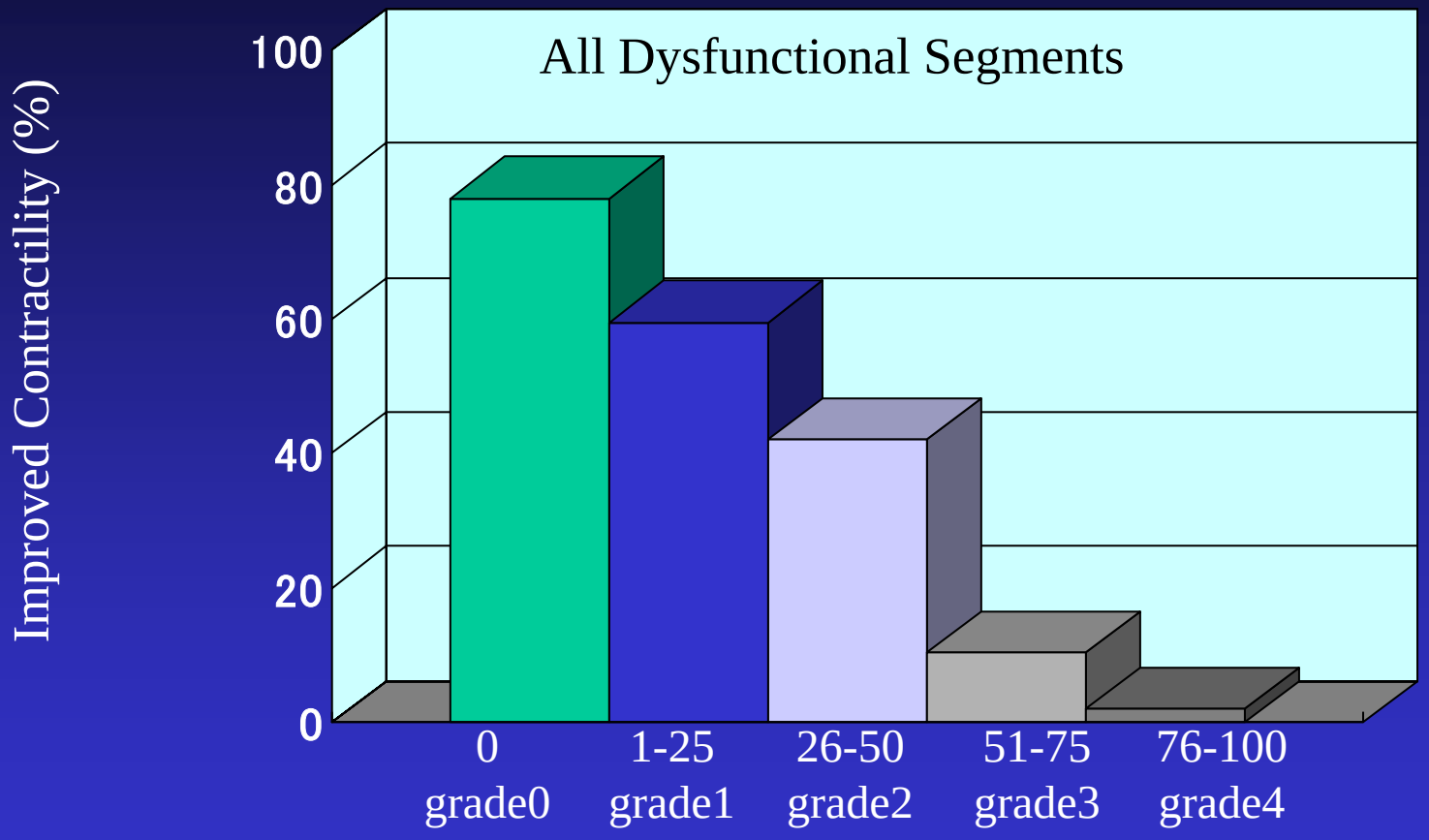


Relationship between hyperemic microvascular resistance and transmural extent of MI by de-MRI

Combowire configuration



Relation between the Transmural Extent of Hyperenhancement before Revasculaization and the Likelihood of Increased Contractility after Revascularization



(Kim RJ, et al; N Eng J Med 2000; 343: 1445-53)

Case 1: 70 y.o., male

Main complaint) chest pain

Coronary risk factor) current smoking

family history of coronary artery disease

P. I.) Feb. 8, 2007 Admission to our hospital with

continuous chest pain lasted > 30 minutes at rest.

ECG: ST segment elavation in aVL, V1-5 leads

Echocardiogaraphy: akinesis in the LAD territory

Emergency CAG:

#6: 99% (collateral flow from RCA), #13: 100% (CTO)

Labo. data (emergency room):

WBC 11500, CRP 0.10mg/dl, CK 43IU/l, CK-MB 13IU/l,

GOT 15IU/l, GPT 16IU/l, LDH 215IU/l, TroponinT(-)

Case 2 : 64 y.o., male

Main Complaint) chest pain

Coronary risk factor) current smoking

P.I.) March 11, 2007 Admission to our hospital with aggravating chest pain at rest

ECG: QS pattern in V1-4 leads, abnomal Q in aVL

ST segment elavation in I, aVL, V1-5 leads

Echocardiogaraphy: akinesis in the LAD territory

Emergency CAG:

#6: 100% (collateral flow ; none)

Labo. data (emergency room):

WBC 9400, CRP0.60mg/dl, CK 1535IU/l, CK-MB 113IU/l, GOT 155IU/l, GPT 38IU/l, LDH 493IU/l, TroponinT(+)