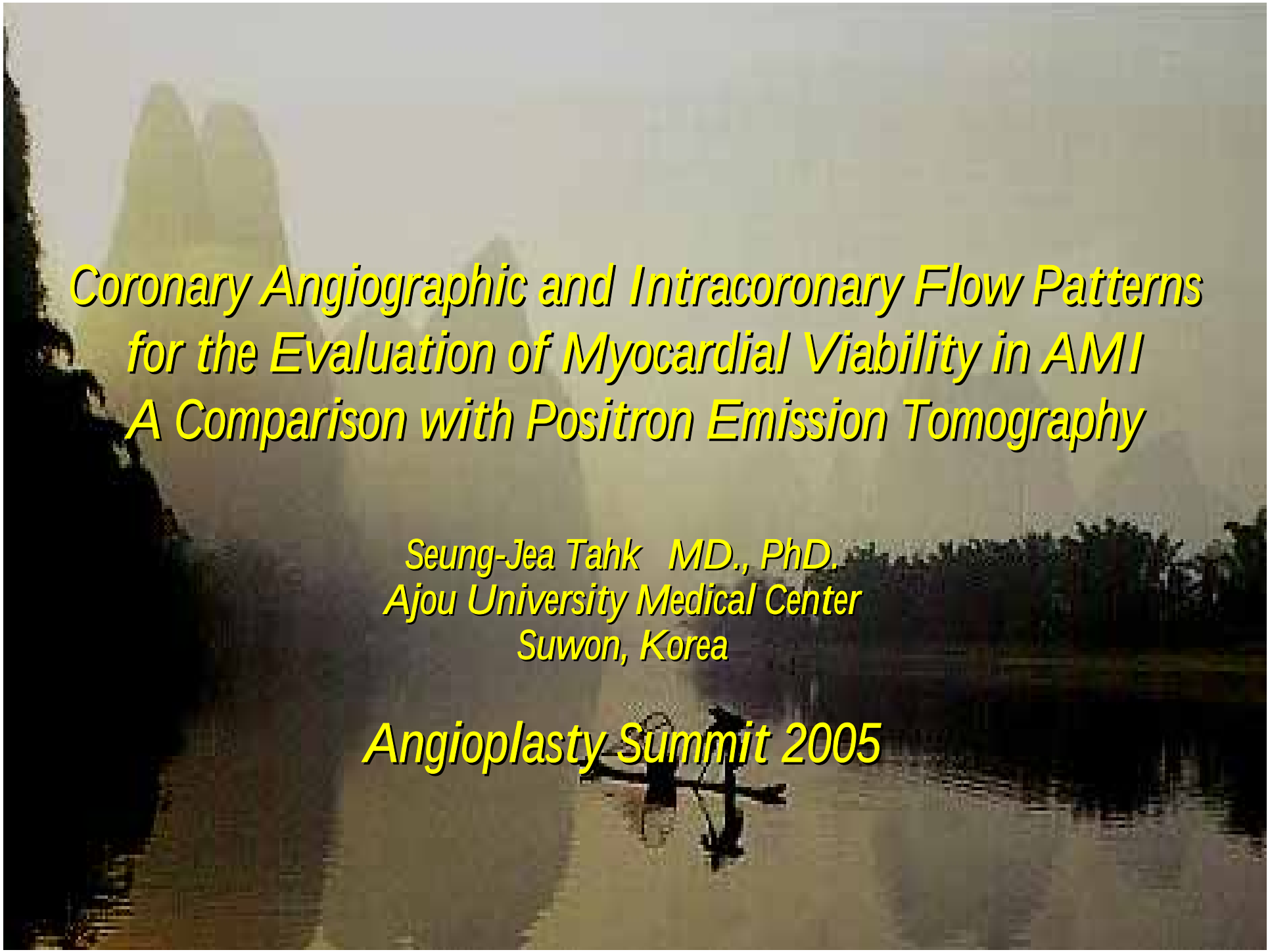


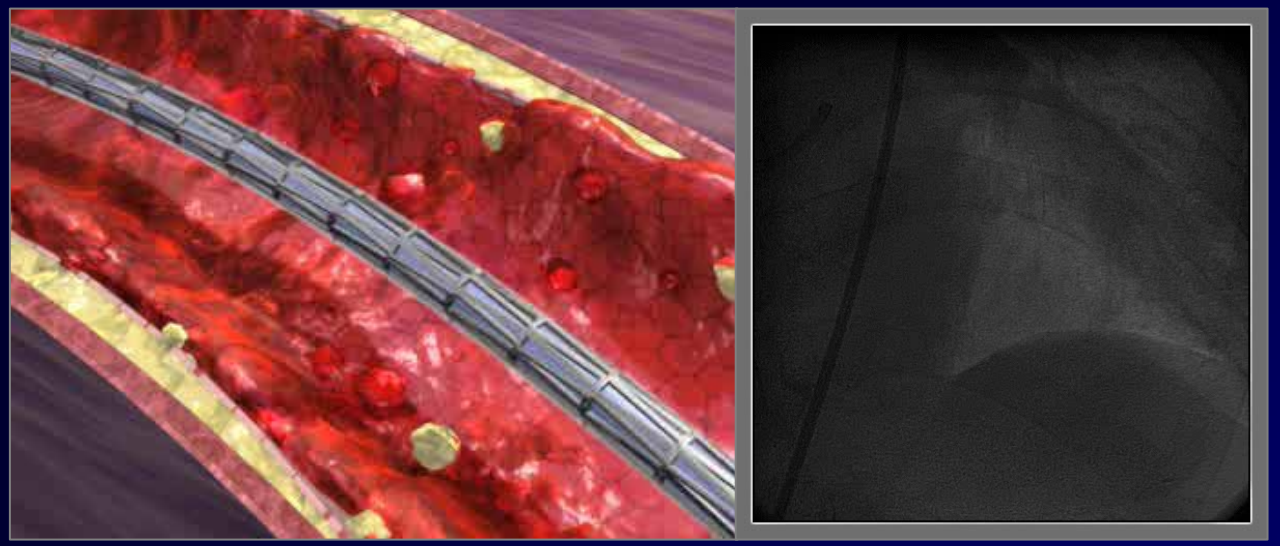
Coronary Angiographic and Intracoronary Flow Patterns for the Evaluation of Myocardial Viability in AMI
A Comparison with Positron Emission Tomography

Seung-Jea Tahk MD., PhD.
Ajou University Medical Center
Suwon, Korea

Angioplasty Summit 2005

Background

- Establishing angiographic epicardial flow after AMI is not always synonymous with tissue-level myocardial perfusion, which is important determinant of left ventricular function change and prognosis after acute myocardial infarction.



Background

- Coronary angiographic and physiologic indices such as..
  - TIMI myocardial perfusion grade
  - Deceleration time of diastolic flow velocity
  - Microvascular resistance index
  - Coronary flow velocity reserve
  - Coronary wedge pressure

  have been known as parameters which represent myocardial viability after AMI.

- ^{18}F-FDG regional uptake on positron emission tomography has been used as a reference standard for myocardial viability.

- This study was designed to evaluate the efficacy of angiographic and physiologic indices for the evaluation of myocardial viability by comparison with PET in AMI patients who received PCI.

Study Population

Inclusion Criteria

- First onset of acute STEMI
- >75% in diameter stenosis, eligible for stenting.
- Residual diameter stenosis<30% after stenting
- Informed consent to perform coronary stenting, intracoronary physiologic study, and PET imaging within 1 week after onset.

Exclusion Criteria

- Cardiogenic shock
- Left main disease
- Atrial fibrillation, SVT or VT, 2nd or 3rd degree AV block

Study Population

- 26 consecutive patients satisfying inclusion criteria were studied.

Age (years)	56 ± 13
Gender (Male, %)	22(84.6%)
Infarct related artery	
Anterior	18(69.2%)
Posterior	1 (3.8%)
Inferior	7 (26.9%)
Time to reperfusion (hr)	21 ± 41
LVEF (%)	50 ± 11
RWMSI	1.54±0.37

Angiographic and Coronary Physiologic Assessment

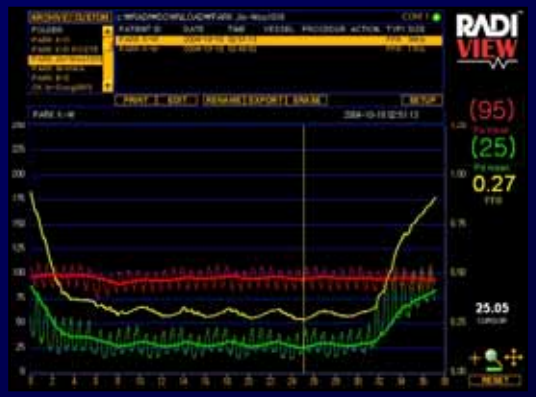
Coronary Angiographic Evaluation

- Quantitative Coronary Angiography
- TIMI Flow
- TIMI Myocardial Perfusion Grades
- Collateral Flow Grades

Coronary Flow Parameters

- Coronary Flow Reserve (CFR) = hAPV / bAPV
- Microvascular Resistance Index (MVRI) = Mean Pcor / APV
- Deceleration Time of Diastolic Flow Velocity (DDT)
- Coronary wedge pressure (Pcw)

Methods



Coronary wedge pressure

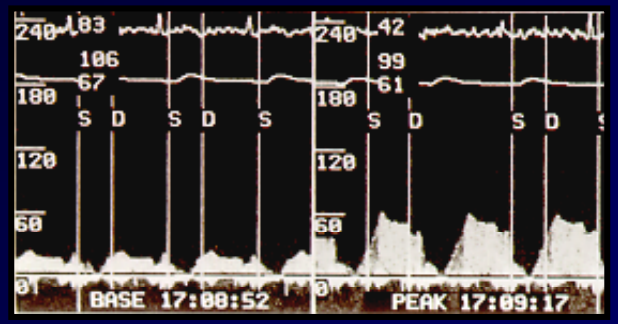
Conventional Balloon Catheter (OWT/Monorail) or Stent Balloon Catheter
Pressure Wire (RADI)

Intracoronary flow measurements

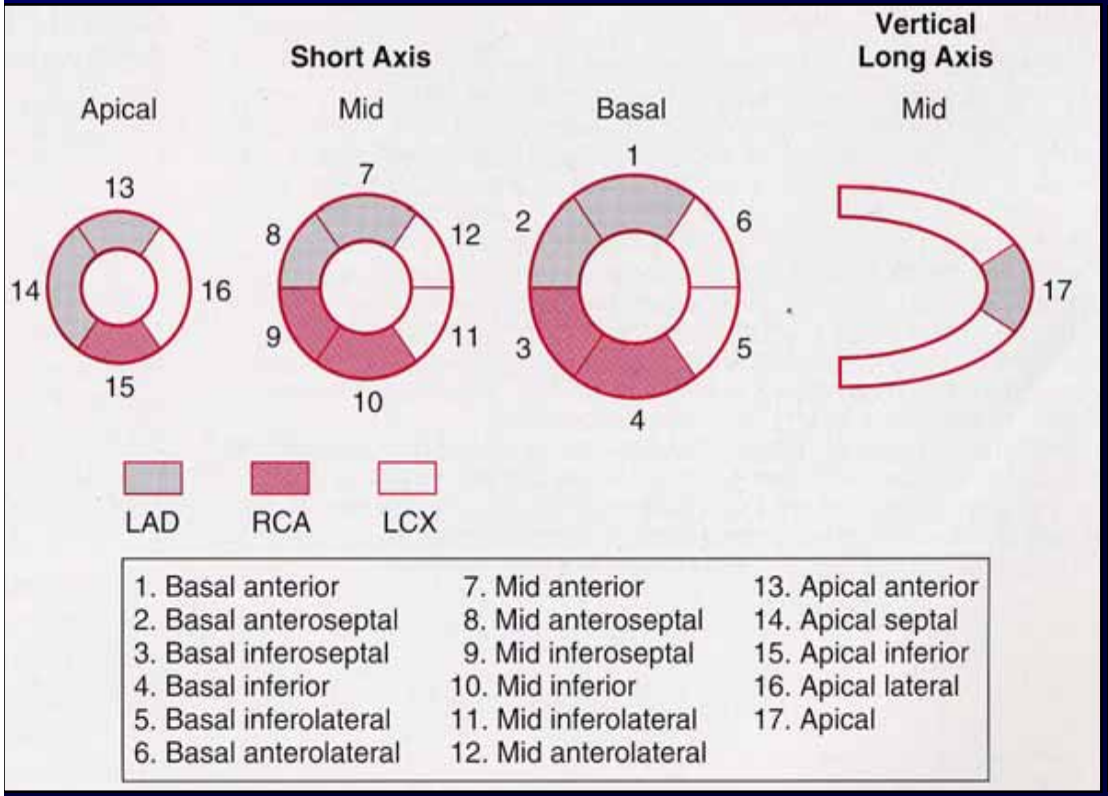
Doppler Guide Wire
FloWire™ (Endosonic)
FloWire XT (JOMETRICS)

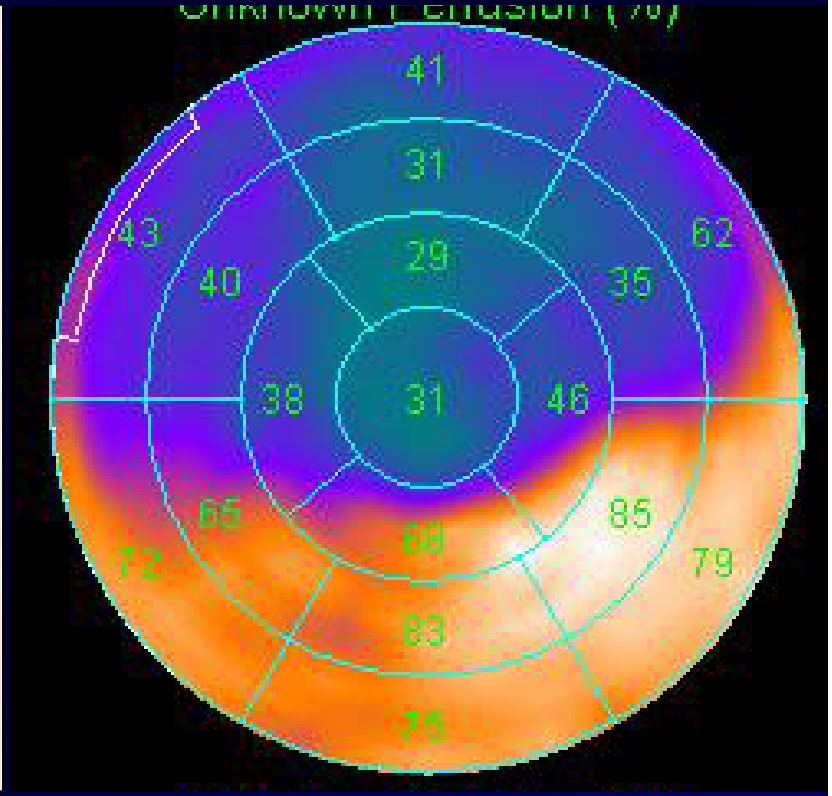
FlowMap® System

Intracoronary Adenosine 24-48μg



PET Imaging





Discovery ST, Combined PET and CT Scan, GE medical system, USA

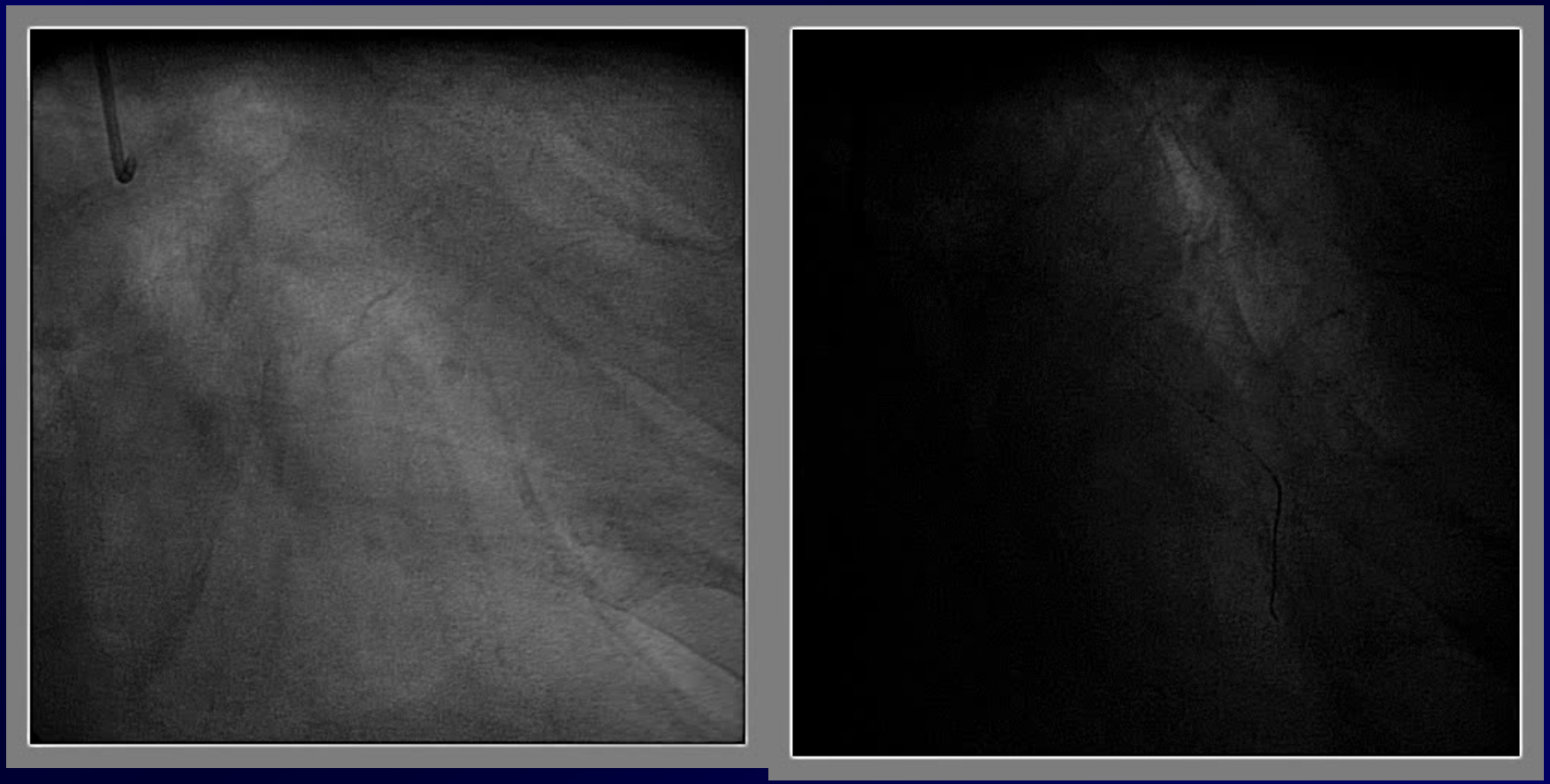
Myocardial viability threshold: 50% or more uptake of ^{18}F-FDG

J Nucl Cardiol 1999;649

Bonow RO et al. Circulation 1991;83:26

Case 1 Coronary Angiography

Acute Anterior STEMI, M/52, Time to reperfusion: 6 hrs, LVEF: 33%



Pre PCI

Post PCI TIMI 2 TMPG 0

OHK IS 7111474

Case 1 Coronary Wedge Pressure

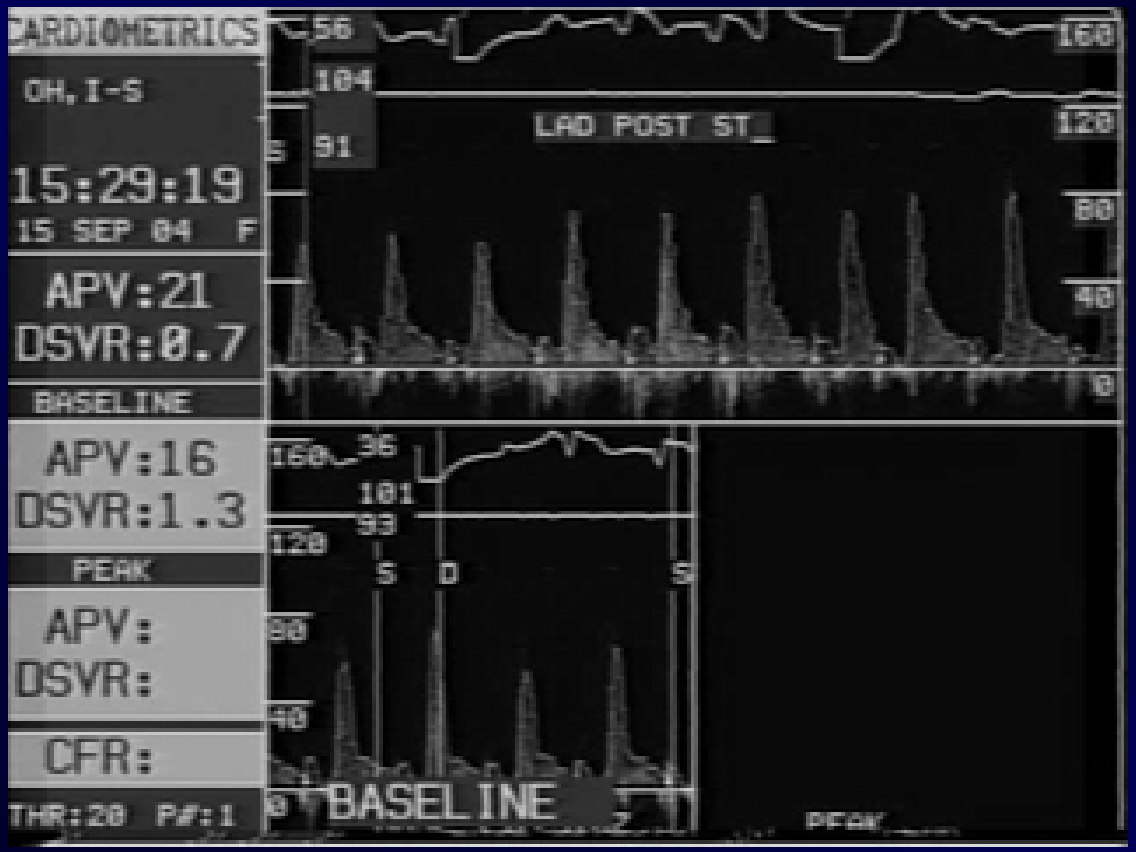
Pa

Pcw

Pcw/Pa

OHK IS 7111474

Case 1 Intracoronary Flow Measurement

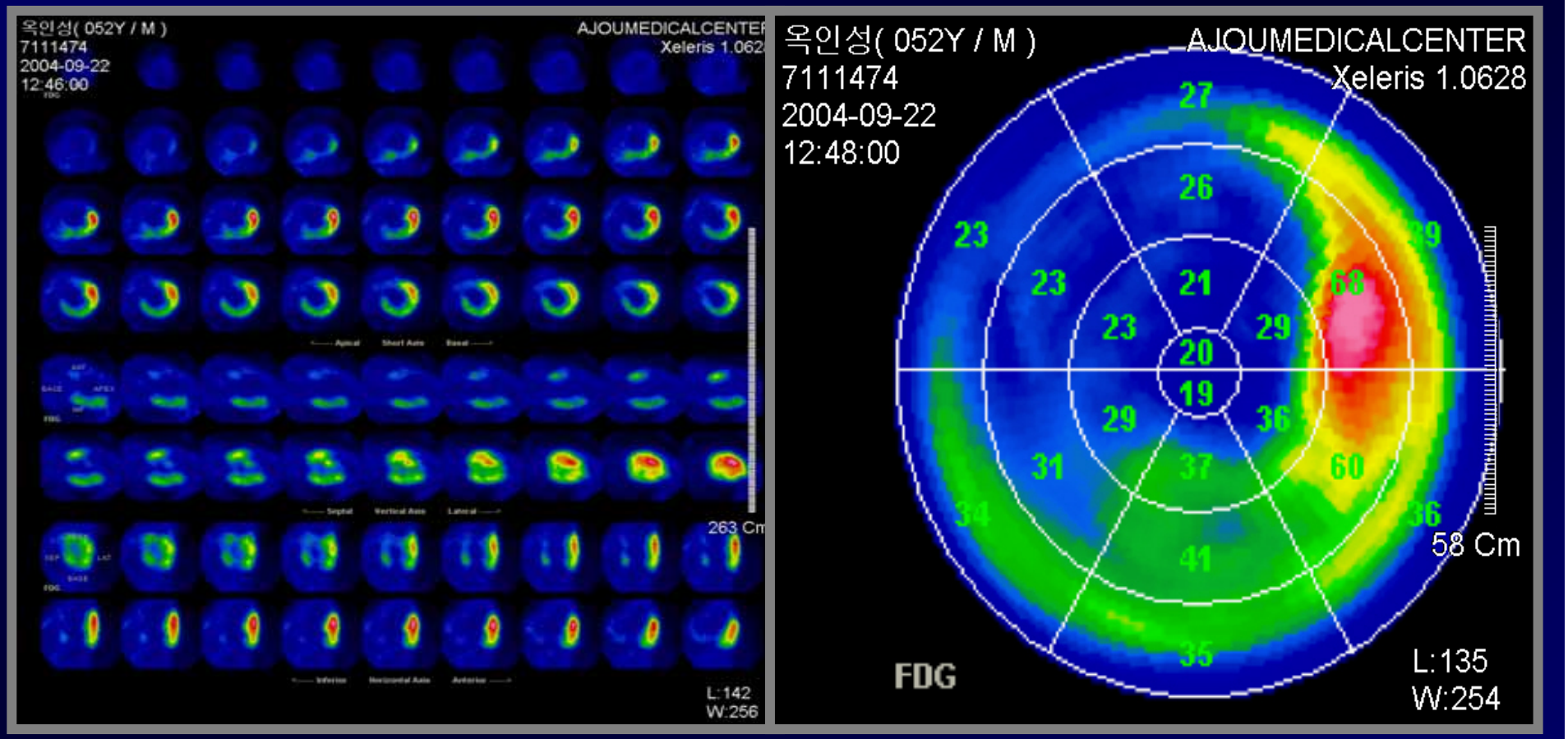


bDDT: 60 ms MVRI: 4.45 mmHg•cm^{-1}•sec^{-1}

hDDT: 60 ms CFR: 1.4

OHK IS 7111474

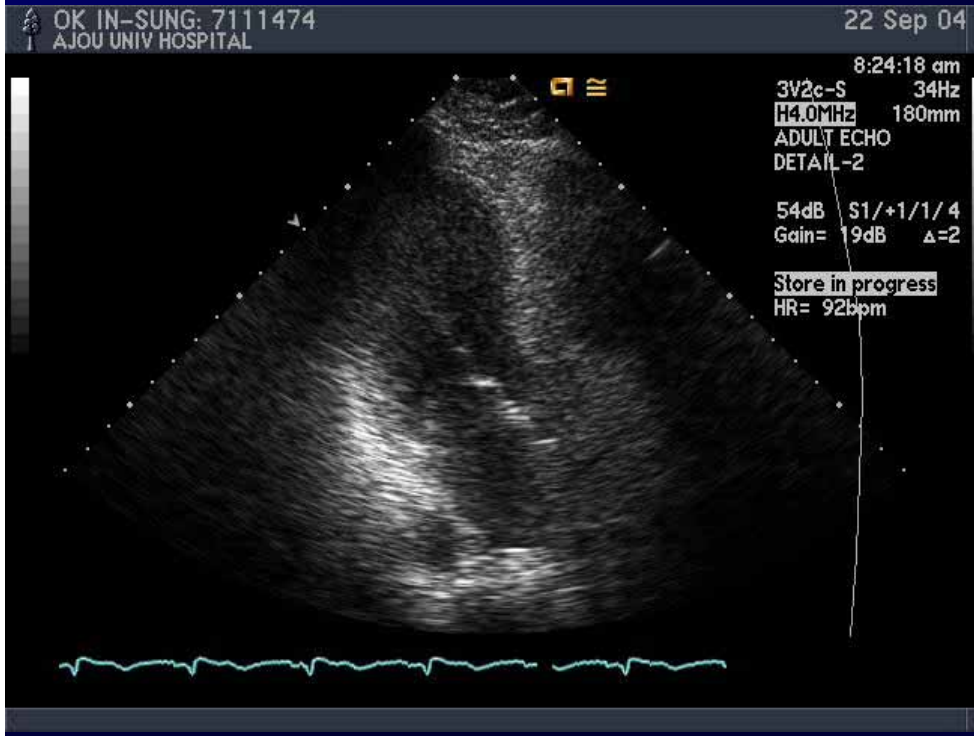
Case 1 FDG PET Imaging



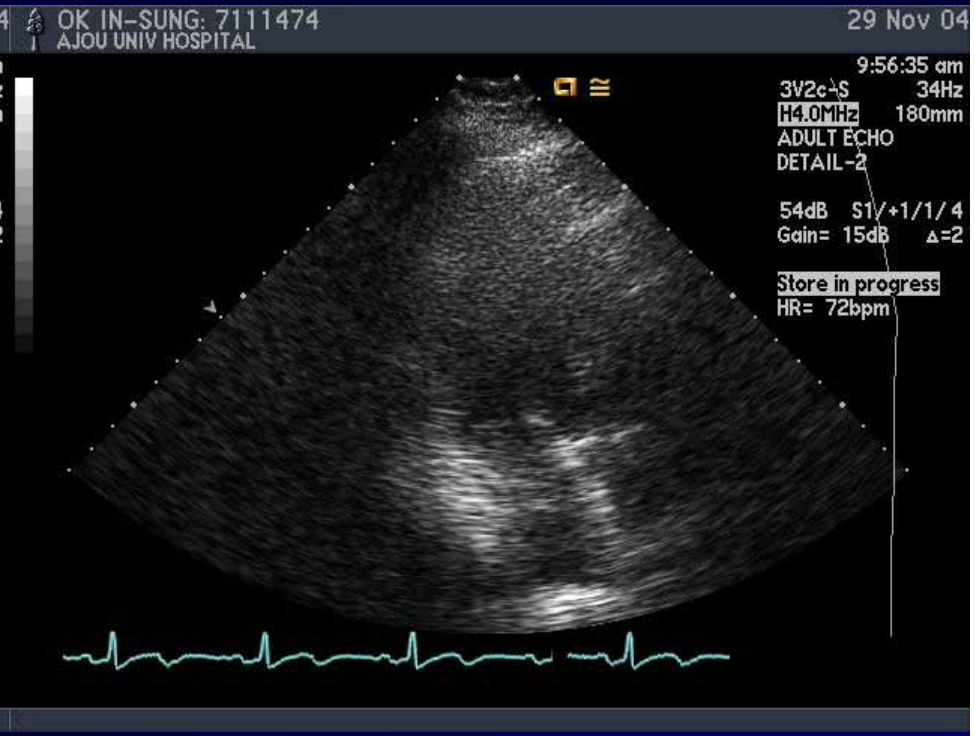
OHK IS 7111474

Case 1 Echocardiography

Post PCI



2 Months FU



	Post PCI	2 Months FU
LVEF (%)	37	40
LVEDV (ml)	95	111
LVESV (ml)	61	69
RWMSI	1.88	1.76

OHK IS 7111474

Case 2 Coronary Angiography

Acute Anterior MI, M/57, Time to reperfusion: 3 hrs, LVEF: 49%

Pre PCI

Post PCI TIMI 2 TMPG 1

Park KD 7225812

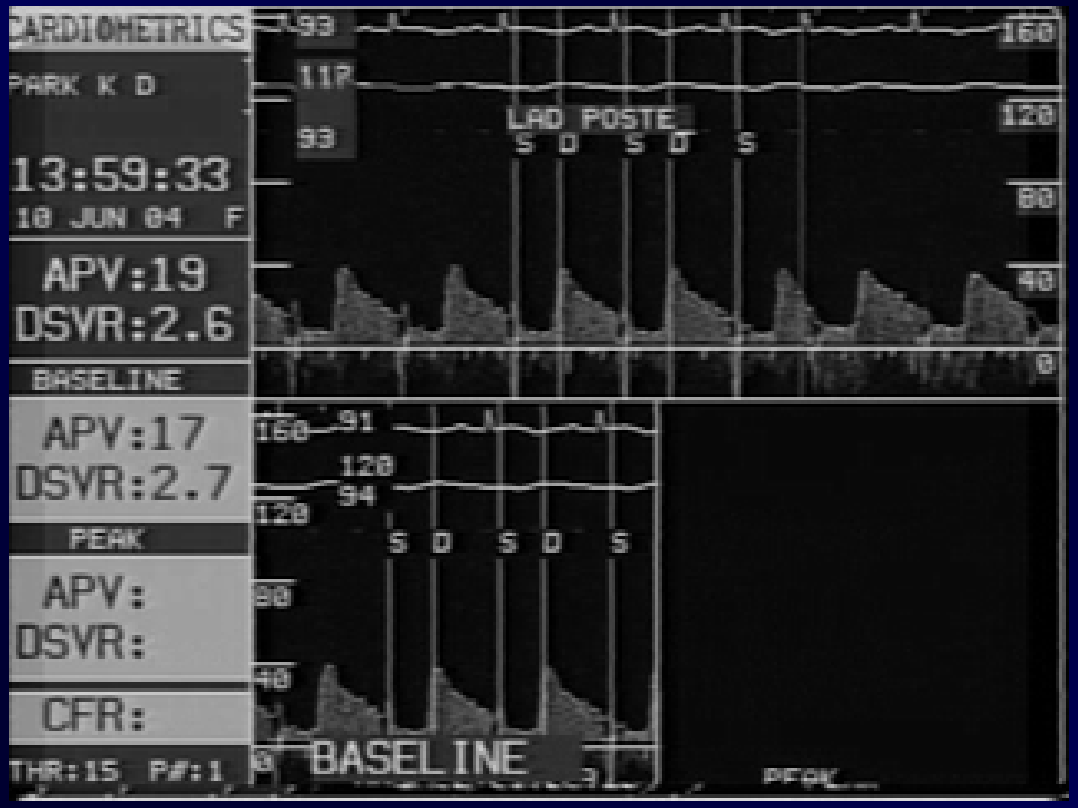
Case 2 Coronary Wedge Pressure

Pa

Pcw

Pcw/Pa

Case 2 Intracoronary Flow Measurement

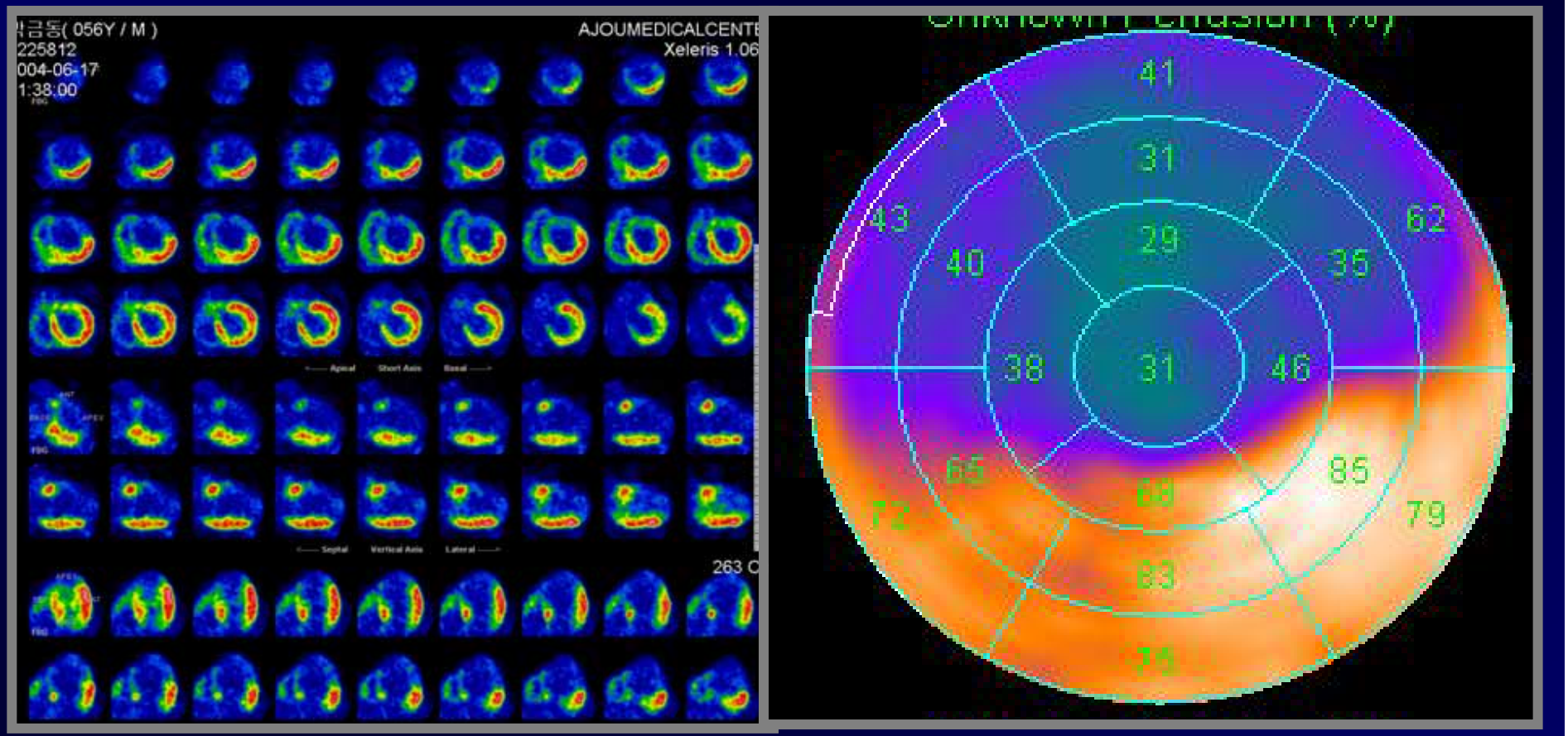


bDDT: 434 ms MVRI: 4.86 mmHg•cm^{-1}•sec^{-1}

hDDT: 495 ms CFR: 1.2

Case 2

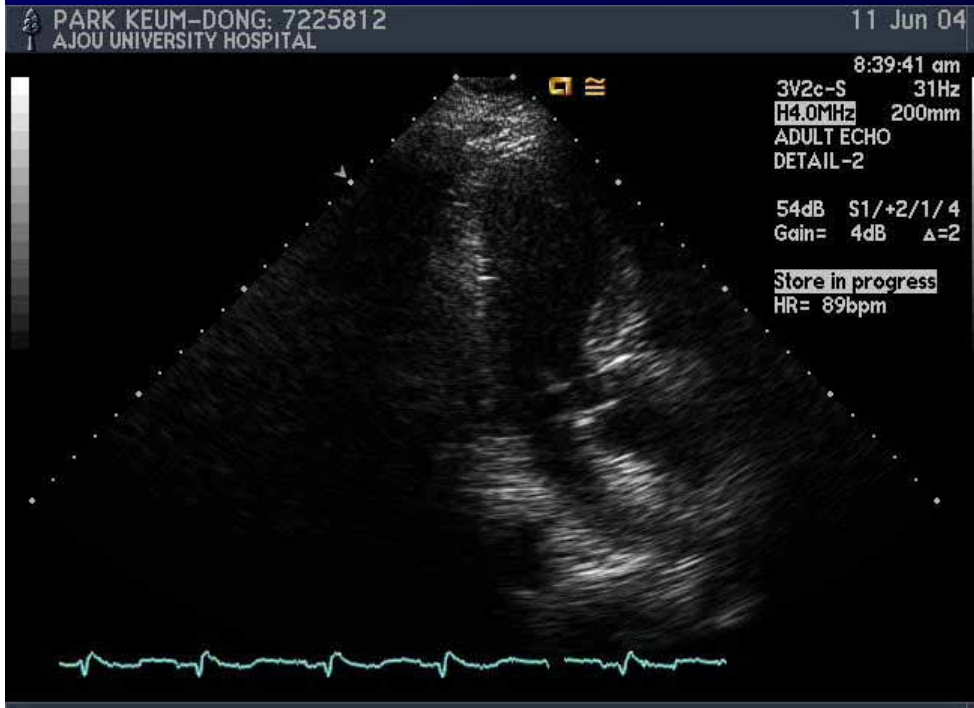
FDG PET Imaging



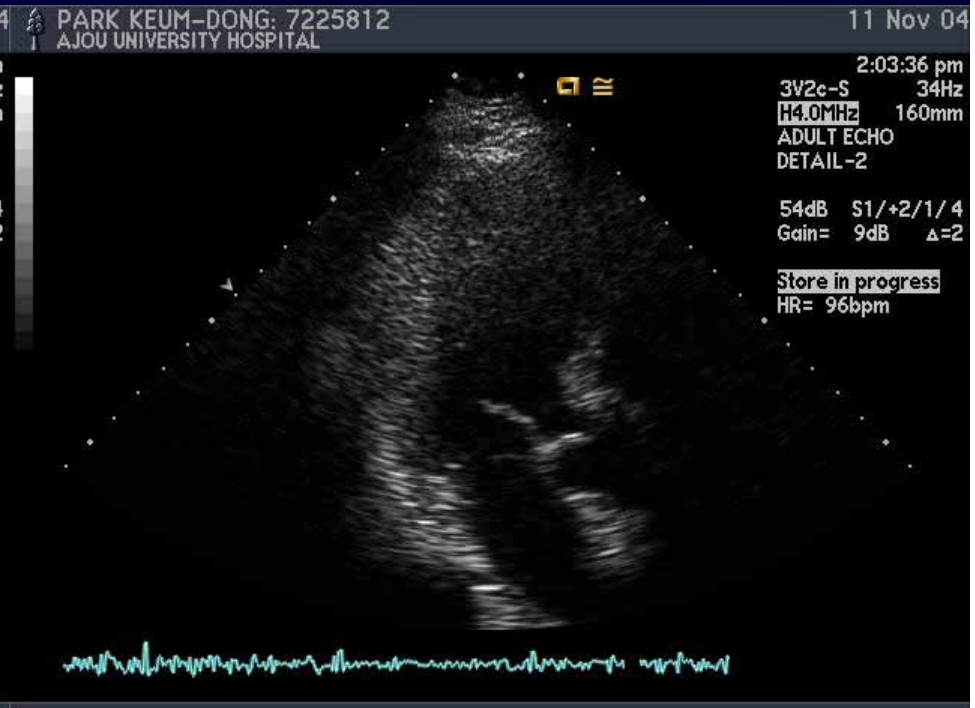
Case 2

Echocardiography

Post PCI



5 Months FU

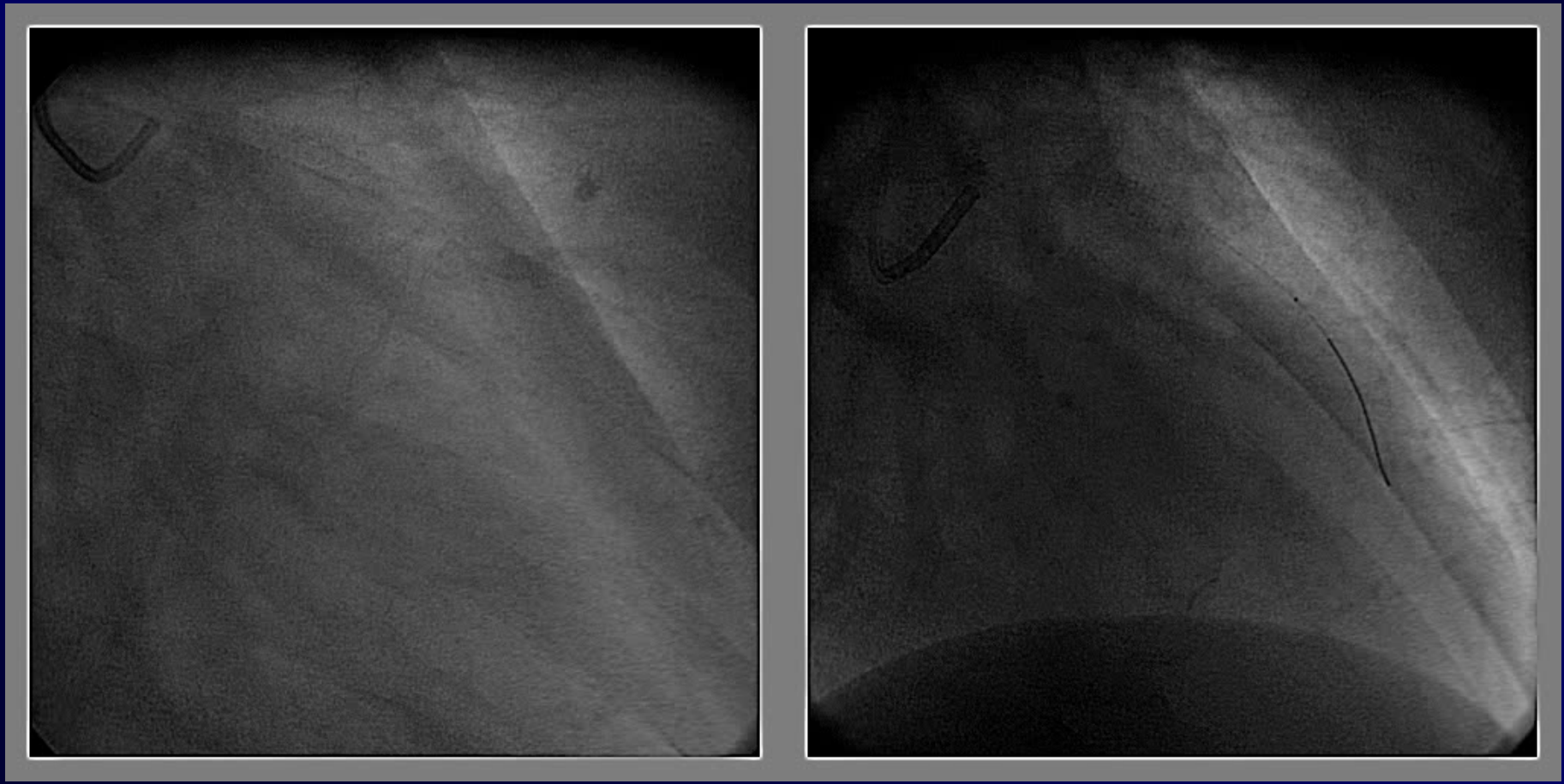


	Post PCI	5 Months FU
LVEF (%)	50	42
LVEDV (ml)	86	90
LVESV (ml)	40	53
RWMSI	1.38	1.44

Park KD 7225812

Case 3 Coronary Angiography

Acute Anterior MI, M/61, Time to reperfusion: 5 hrs, LVEF: 44%



Pre PCI

Post PCI TIMI 3 TMPG 3

Park KW 708697

Ajou University Medical Center

Case 3 Coronary Wedge Pressure

Pa

Pcw

Pcw/Pa

Park KW 708697

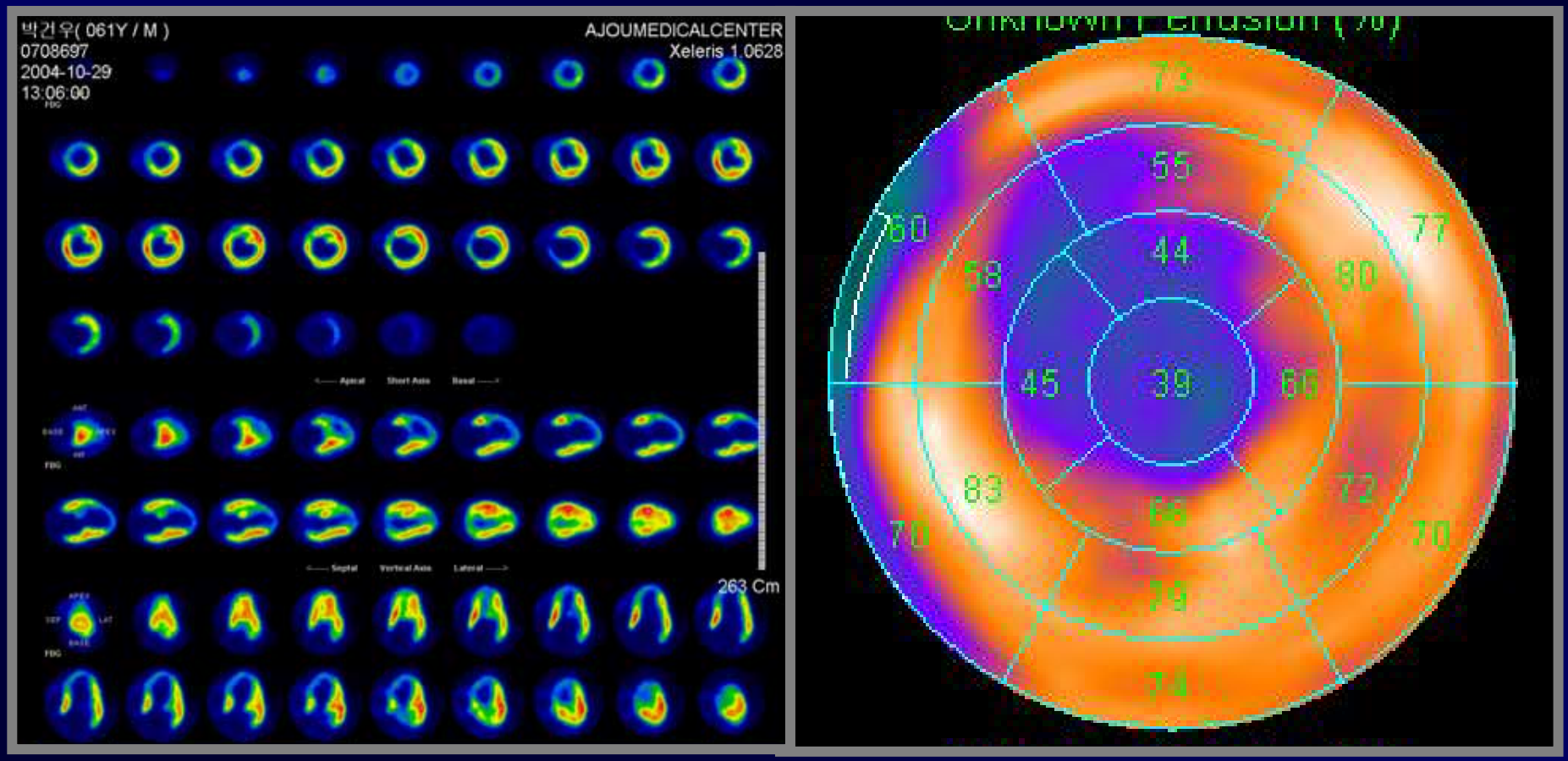
Case 3 Intracoronary Flow Measurement

bDDT: 733 ms MVRI: 3.56 mmHg•cm^{-1}•sec^{-1}

hDDT: 766 ms CFR: 2.3

Case 3

FDG PET Imaging

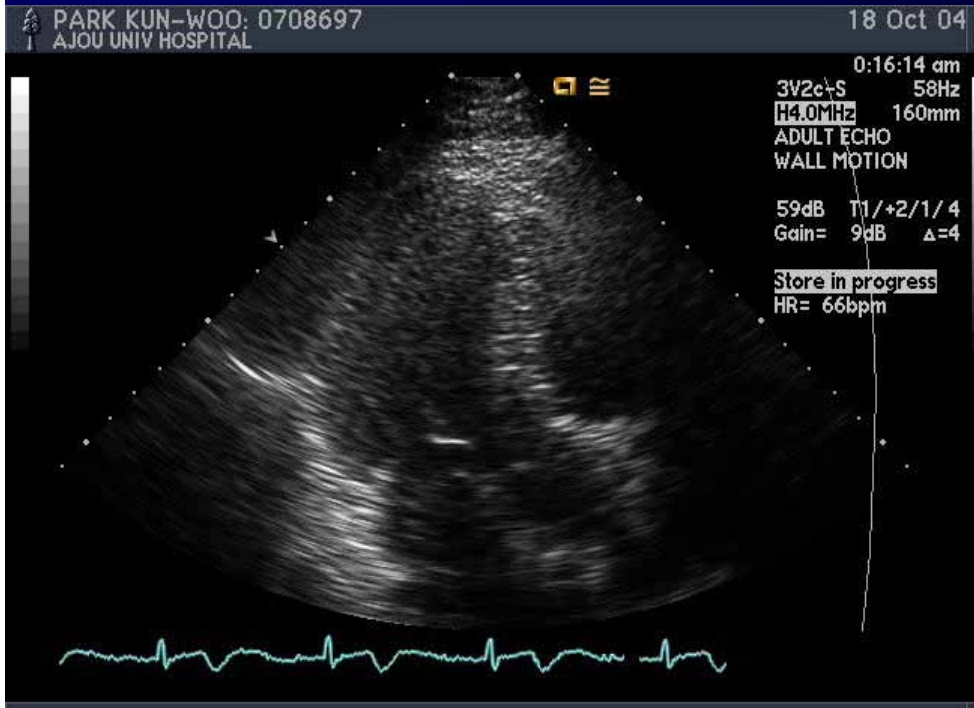


Park KW 708697

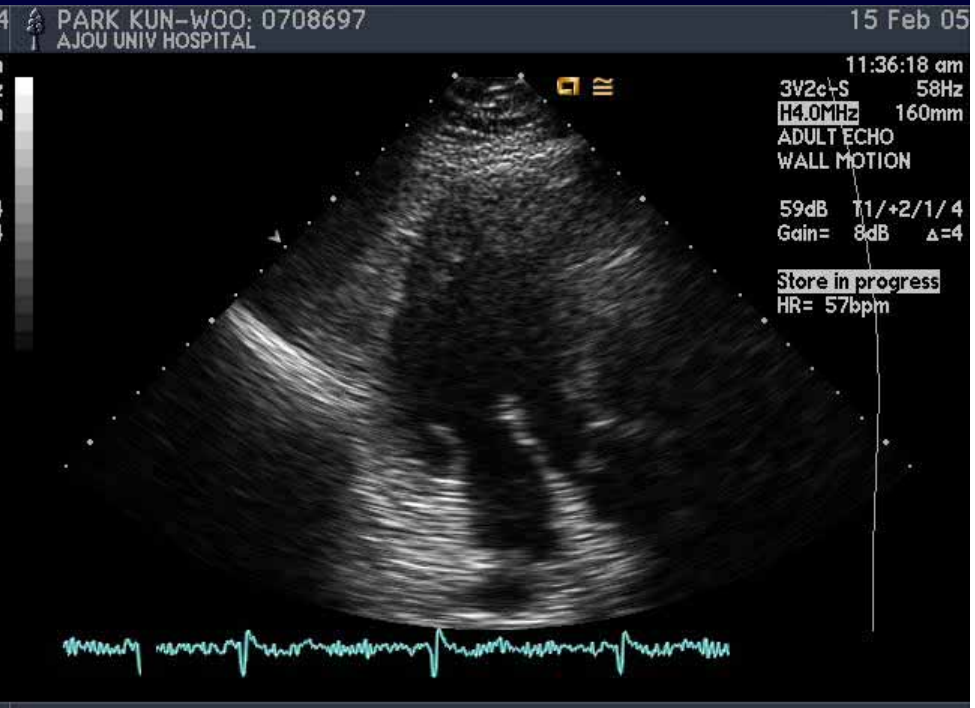
Case 3

Echocardiography

Post PCI



4 Months FU



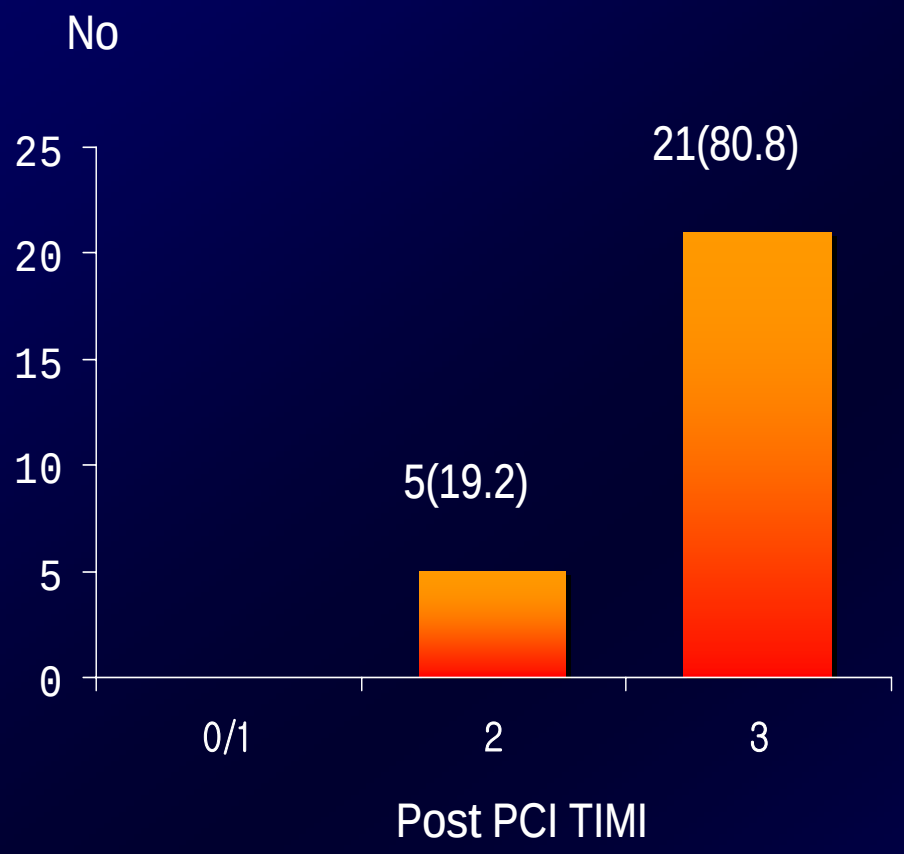
LVEF (%)	47	60
LVEDV (ml)	86	87
LVESV (ml)	48	38
RWMSI	1.26	1.13

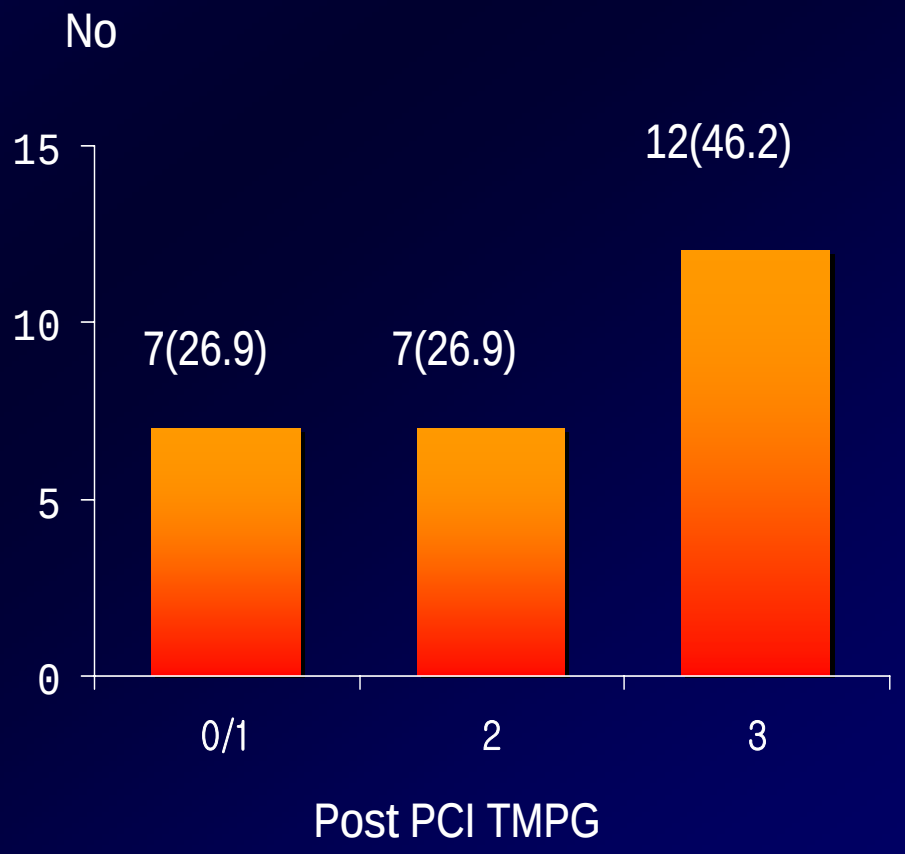
Park KW 708697

Angiographic Findings

Pre-PCI	
MLD (mm)	0.30 ± 0.33
DS (%)	92 ± 10
Collateral Flow	
Grade 0	16(61.5%)
Grade 1	6 (21.3%)
Grade 2	4 (15.4%)
Grade 3	0 (0.0%)
Post-PCI (Stent)	
MLD (mm)	3.14 ± 0.38
DS (%)	9 ± 5
Reference Vessel Size (mm)	3.46 ± 0.43

Post PCI TIMI and TMP Grades

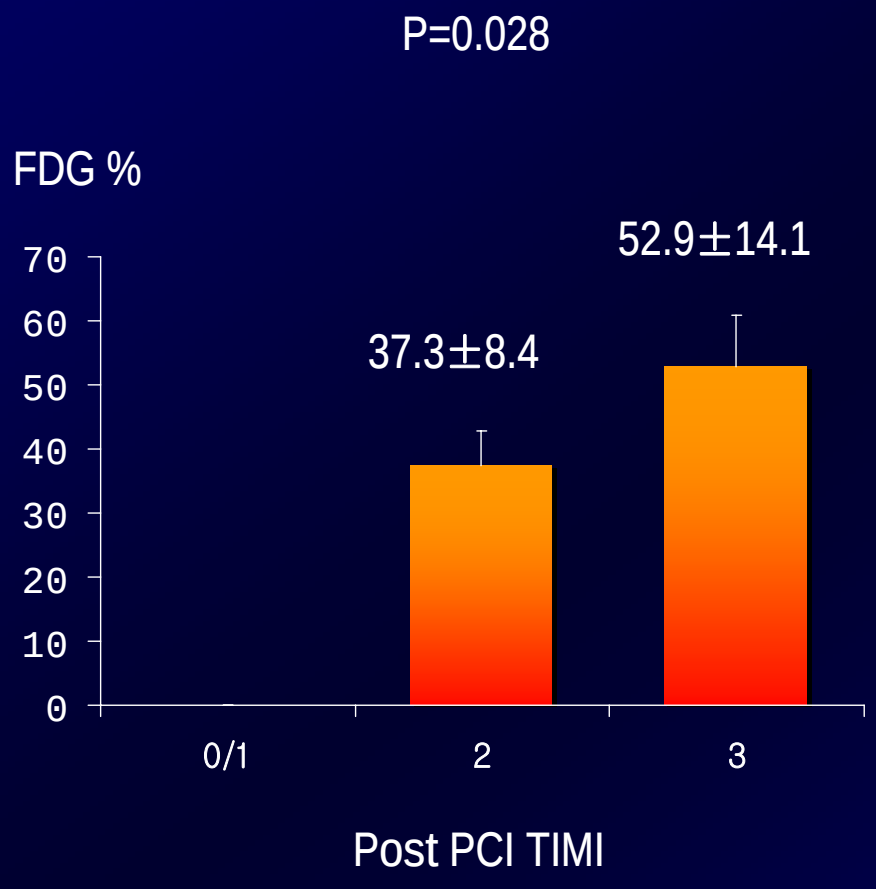


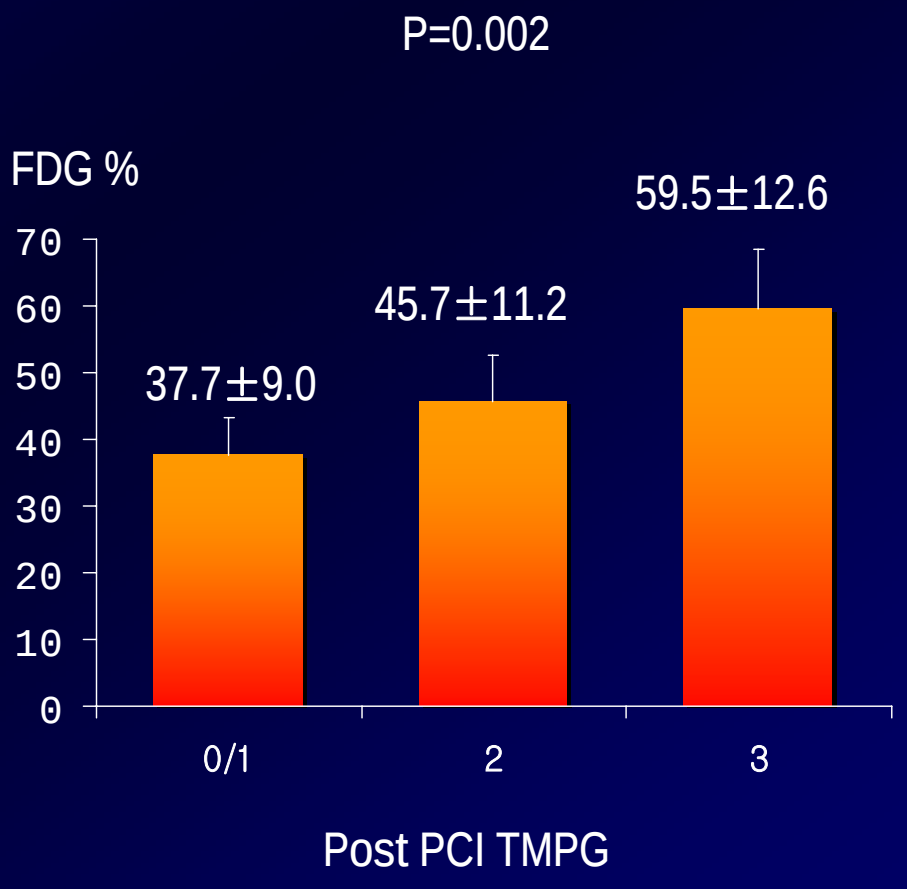


Physiologic and PET Findings

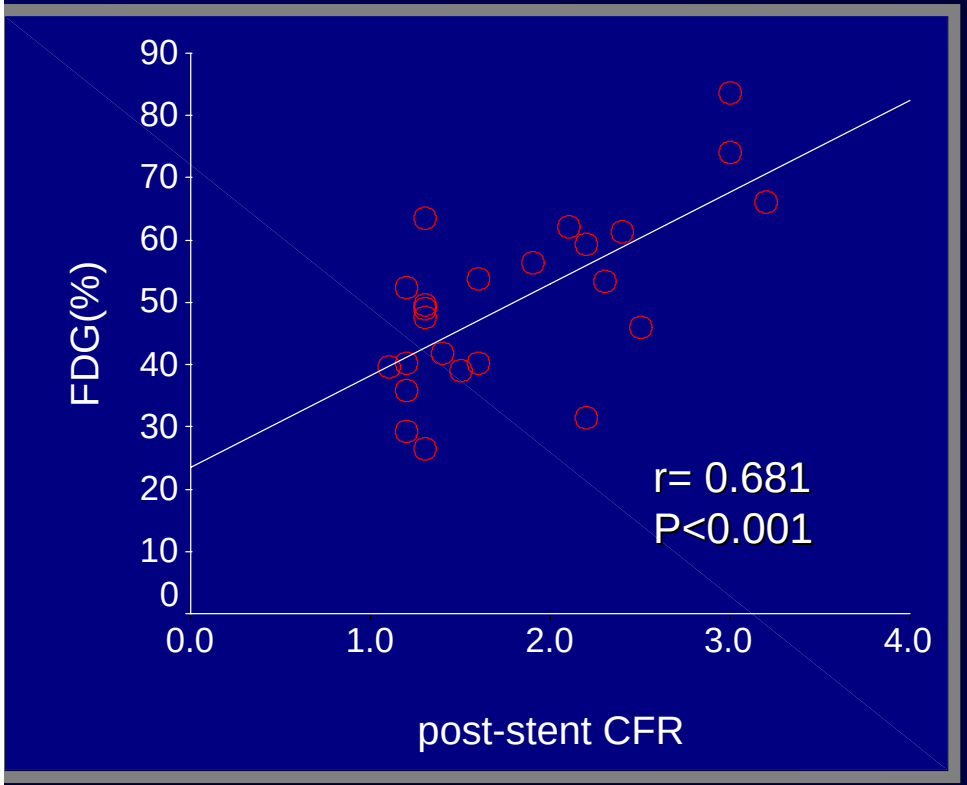
Total Patients(26)	
bDDT (ms)	644.7 ± 360.2
hDDT (ms)	685.6 ± 340.0
hMVRI ($mmHg.cm^{-1}.sec^{-1}$)	2.90 ± 1.53
CFR	1.80 ± 0.66
Pcw (mmHg)	29.5 ± 10.8
Pcw/Pa	0.30 ± 0.10
%FDG Uptake (%)	49.9 ± 14.5

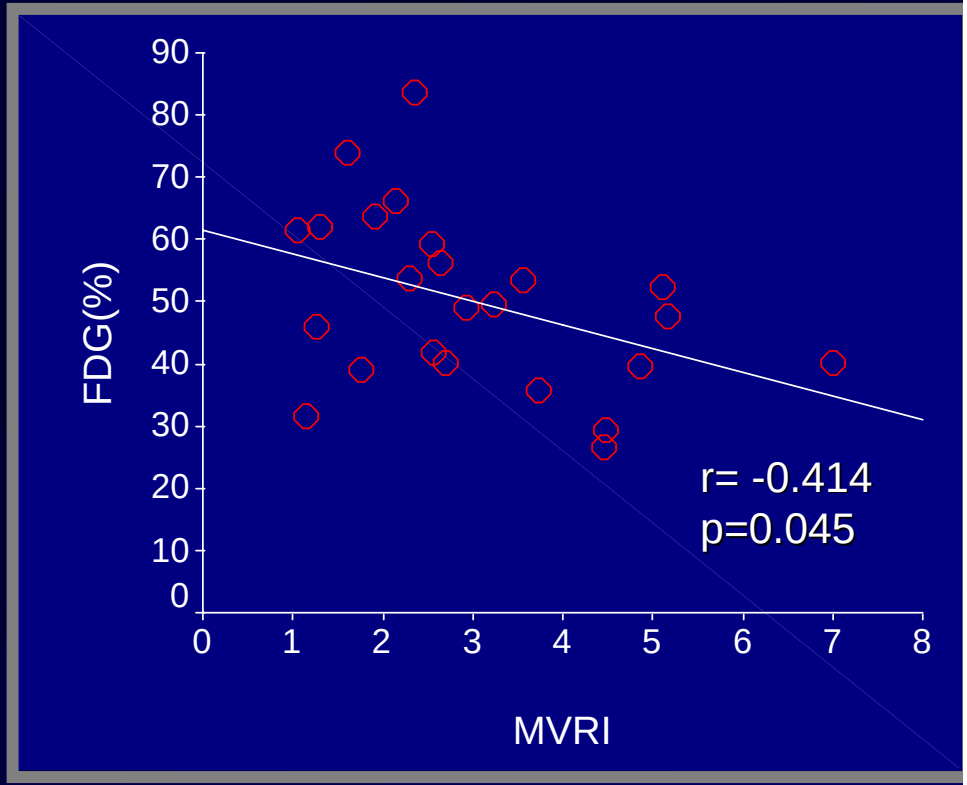
Viability on PET
%FDG Uptake and Angiographic Parameters



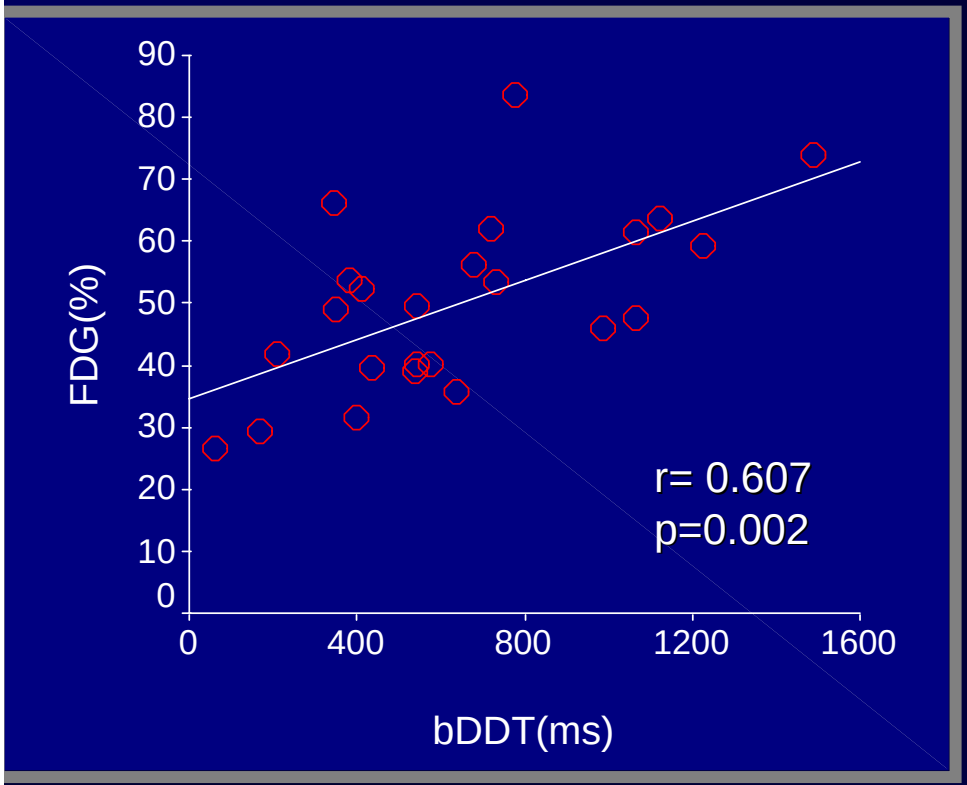


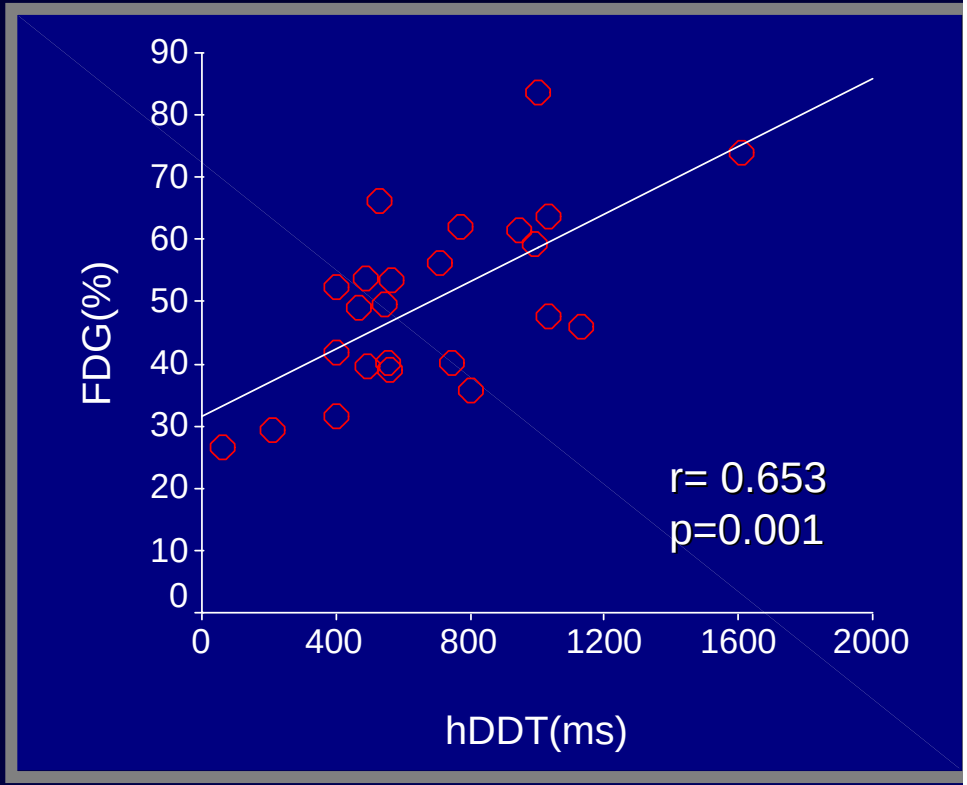
Viability on PET
%FDG Uptake and Physiologic Parameters



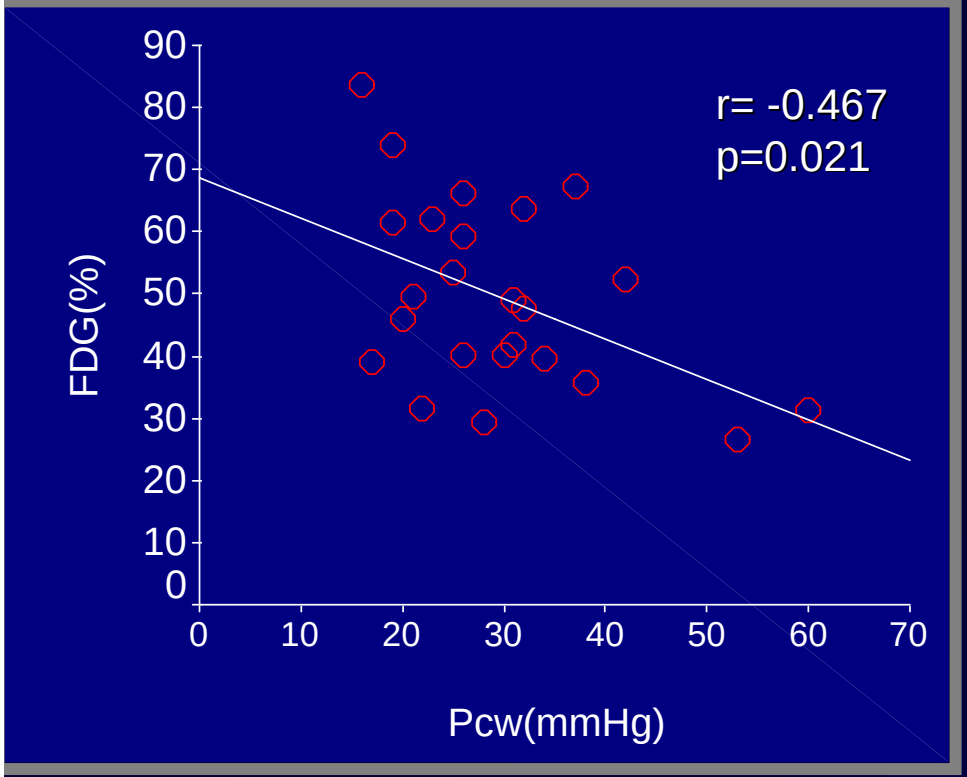


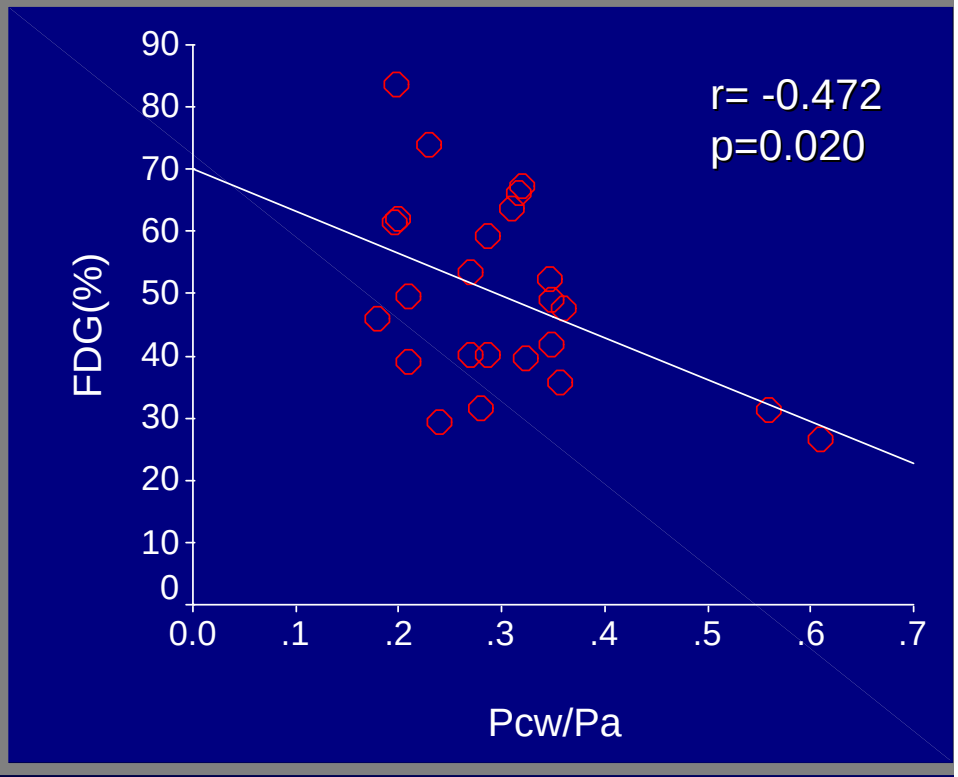
Viability on PET
%FDG Uptake and Physiologic Parameters



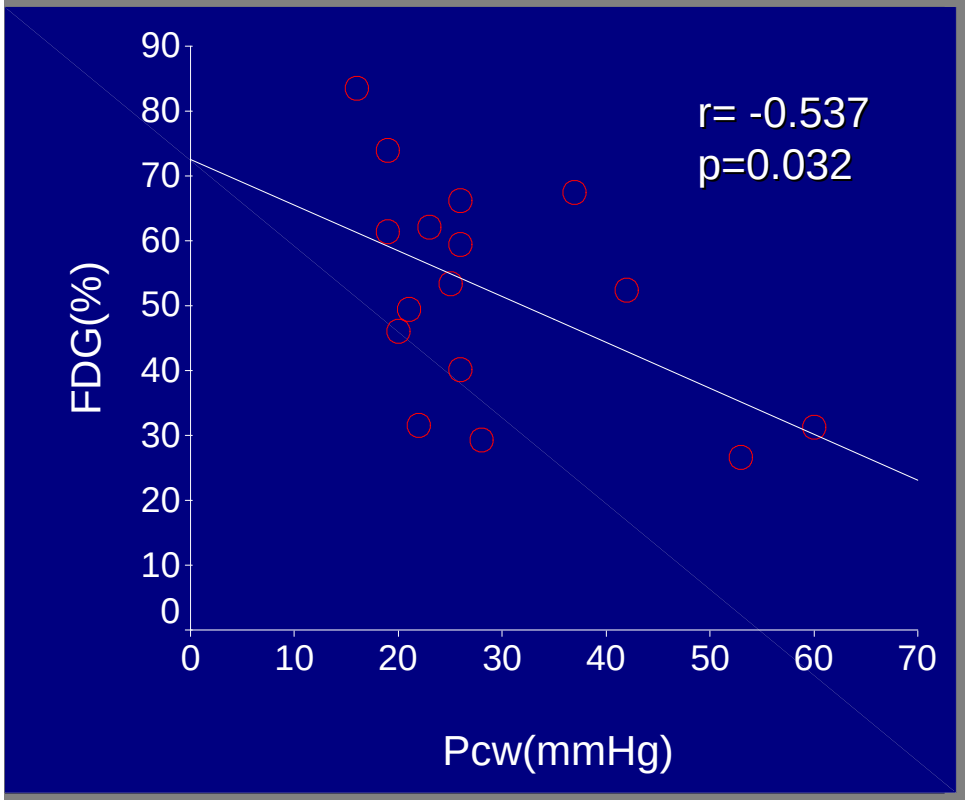


Viability on PET
%FDG Uptake and Physiologic Parameters

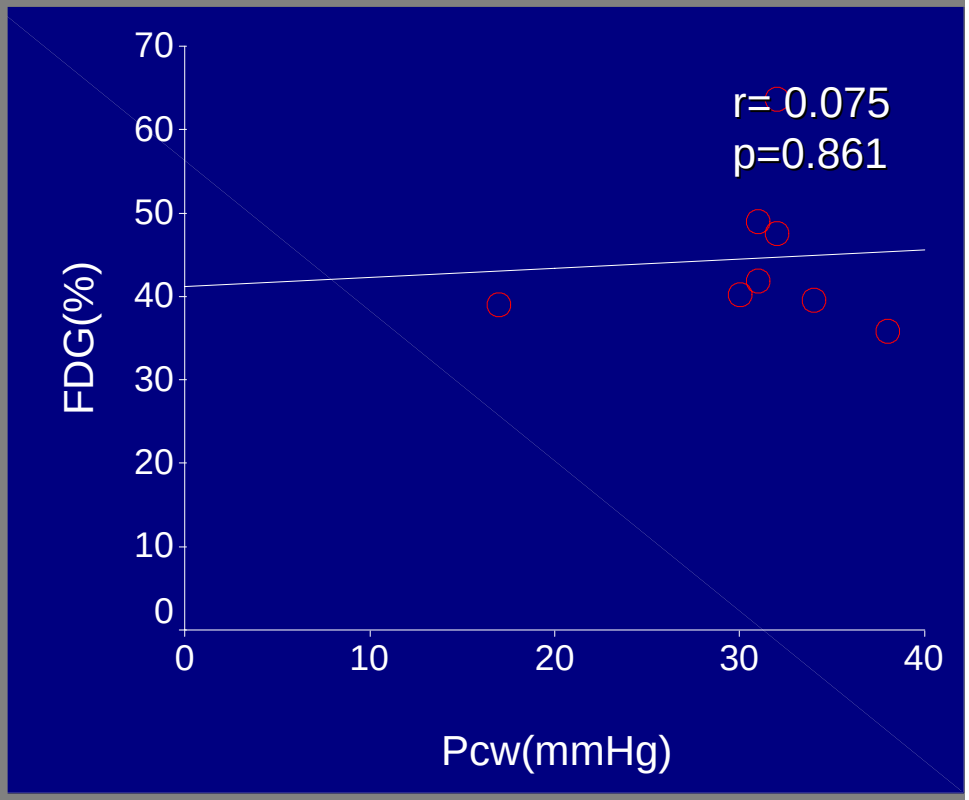




Viability on PET
%FDG Uptake and Physiologic Parameters



Patients without Collaterals



Patients with Collaterals

Viability on PET
Clinical Characteristics

	Viable(11)	Non Viable(15)	p value
Age	56 ± 15	56 ± 12	0.929
Gender (Male, %)	9(81.8%)	13(86.7%)	1.000
Hypertension	4(36.4%)	8(53.3%)	0.453
Diabetes	3(27.3%)	4(26.7%)	1.000
Smoking	7(63.6%)	11(73.3%)	0.683
Dyslipidemia	1(9.1%)	2(13.3%)	1.000
CK	1801 ± 1742	4311 ± 3815	0.081
CK-MB	204 ± 190	321 ± 151	0.126
LVEF(%)	55 ± 10	47 ± 11	0.078
RWMSI	1.30 ± 0.18	1.69 ± 0.38	0.002
%FDG Uptake	63.8 ± 9.0	39.8 ± 7.7	<0.001

Myocardial viability threshold: 50% or more uptake of ^{18}F-FDG

Viability on PET
Angiographic Characteristics

	Viable(11)	Non Viable(15)	P value
IRA			0.484
LAD	7(63.6%)	11(73.3%)	
RCA	1(9.1%)	0(0.0%)	
LCx	3(27.3%)	4(26.7%)	
Pre-PCI			
MLD (mm)	0.49 ± 0.35	0.17 ± 0.26	0.016
DS (%)	86.2 ± 10.2	95.1 ± 7.5	0.017
Post-PCI			
MLD (mm)	3.20 ± 0.35	3.10 ± 0.41	0.528
DS (%)	9.7 ± 4.7	9.2 ± 4.7	0.785
Ref. VD (mm)	3.56 ± 0.31	3.39 ± 0.48	0.323

Myocardial viability threshold: 50% or more uptake of ^{18}F-FDG

Viability on PET
Physiologic Parameters

	Viable (11)	Non-Viable (15)	p Value
bDDT	854 ± 366	495 ± 280	0.012
hDDT	865 ± 334	557 ± 292	0.025
hMVRI	2.14 ± 0.72	3.60 ± 1.68	0.009
CFR	2.30 ± 0.62	1.45 ± 1.41	0.001
Pcw	23.3 ± 5.12	32.6 ± 11.6	0.042
Pcw/Pa	0.25 ± 0.05	0.33 ± 0.12	0.088

Myocardial viability threshold: 50% or more uptake of ^{18}F-FDG

Agreement between Angiographic/Physiologic Parameters and Viability on PET

Parameters	Agreement	Sensitivity	Specificity	κ value
TIMI(0-2/3)	61.5	100.0	33.3	0.297
TMPG(0-2/3)	88.5	90.9	86.7	0.776
CFR (1.5)	83.3	90.0	78.6	0.667
bDDT (637)	83.3	80.0	85.7	0.657
hDDT (560)	75.0	80.0	71.4	0.500
MVRI (2.64)	79.2	90.0	71.4	0.589
Pcw (26)	70.8	77.8	66.7	0.417
Pcw/Pa (0.31)	62.5	77.8	53.3	0.280

( ) best cut-off value from receiver operating curve analysis

Conclusions

- In AMI patients who received PCI, on-site coronary angiographic and physiologic indices including,
  - TIMI myocardial perfusion grade
  - Deceleration time of diastolic flow velocity
  - Microvascular resistance index
  - Coronary flow velocity reserve
  - Coronary wedge pressure

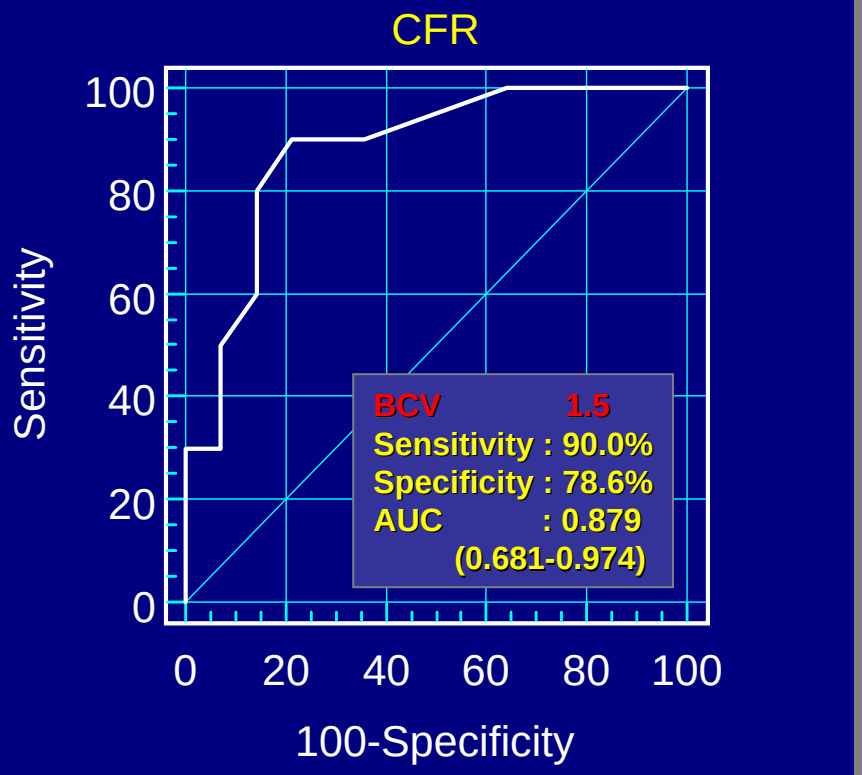
  showed significant correlations with myocardial viability on ^{18}F-FDG PET imaging, and should be considered as important prognostic factors.

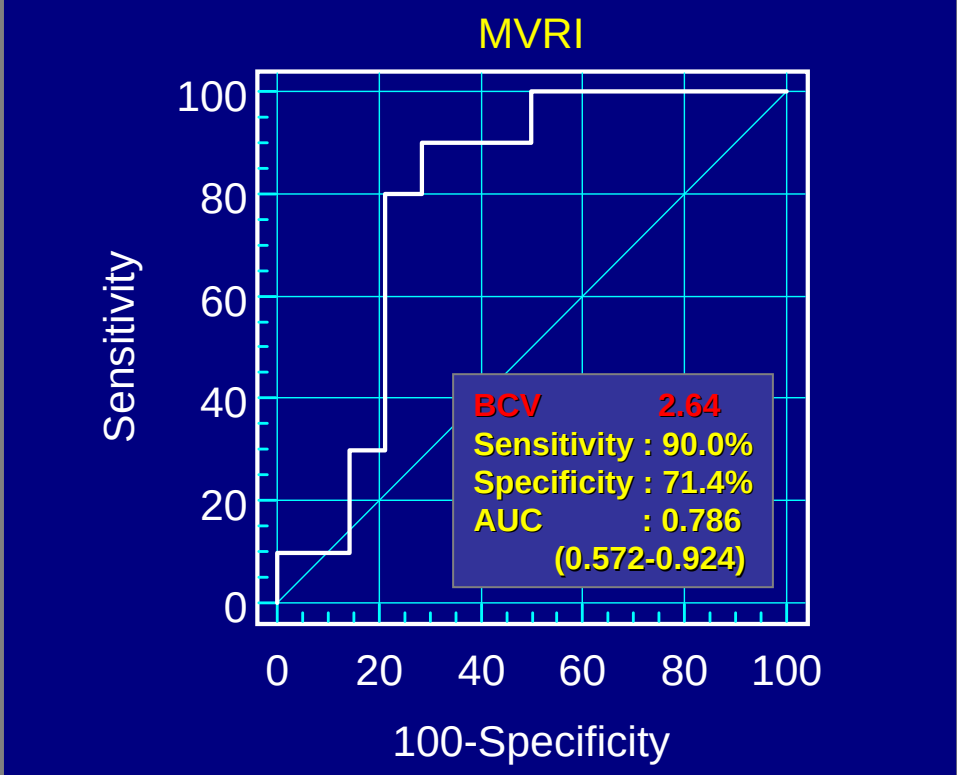
- Simply assess myocardial viability and prognosis with a little longer final angiography after primary PCI …

Agreement between Angiographic Parameters and Viability on PET

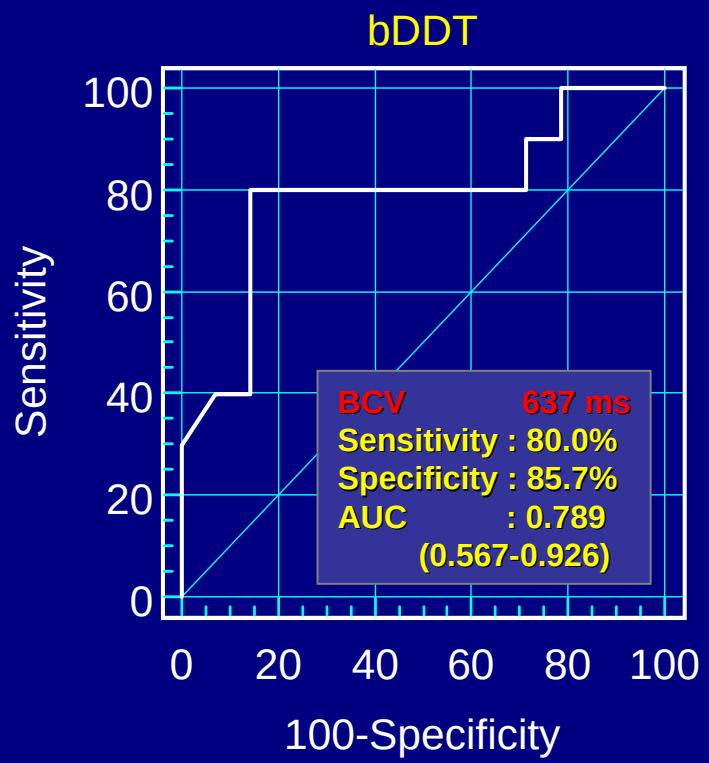
		Viable	Non-Viable	p-value
Post PCI TIMI	0-2	0	5	0.053
	3	11	11	
		11	15	
Post PCI TMPG	0-2	1	13	<0.001
	3	10	2	
		11	15	

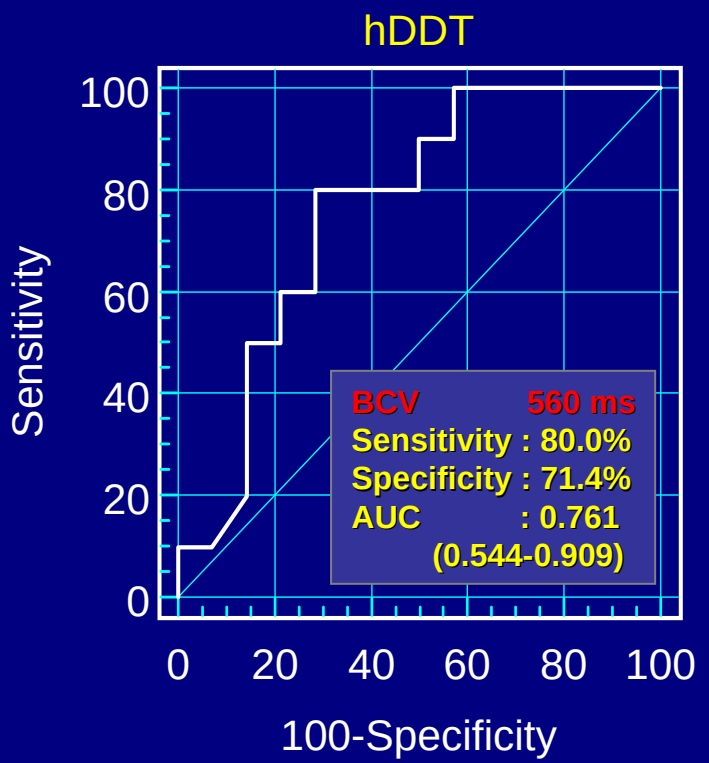
Agreement between Physiologic Parameters and Viability on PET
Receiver Operating Curve Analysis



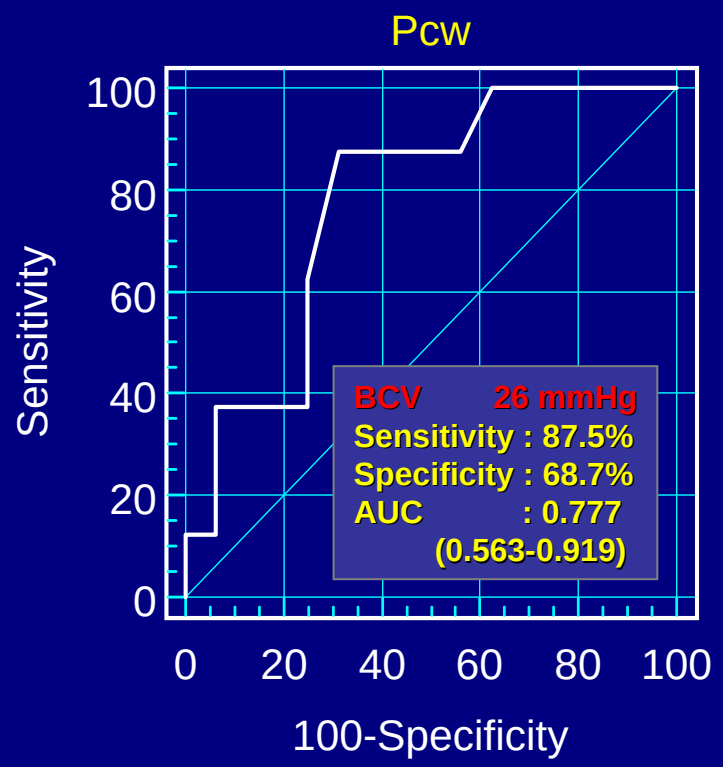


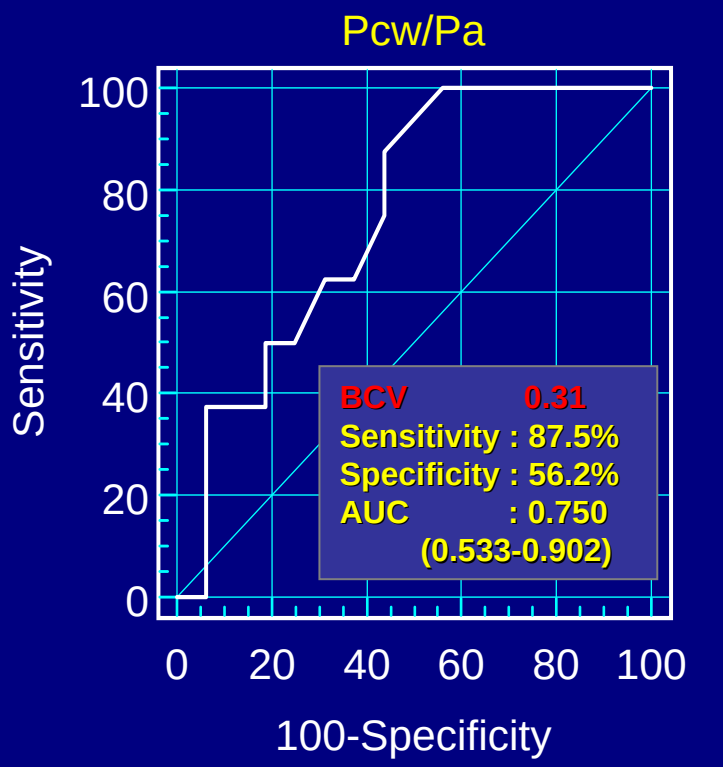
Agreement between Physiologic Parameters and Viability on PET
Receiver Operating Curve Analysis





Agreement between Physiologic Parameters and Viability on PET
Receiver Operating Curve Analysis





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  - TIMI myocardial perfusion grade
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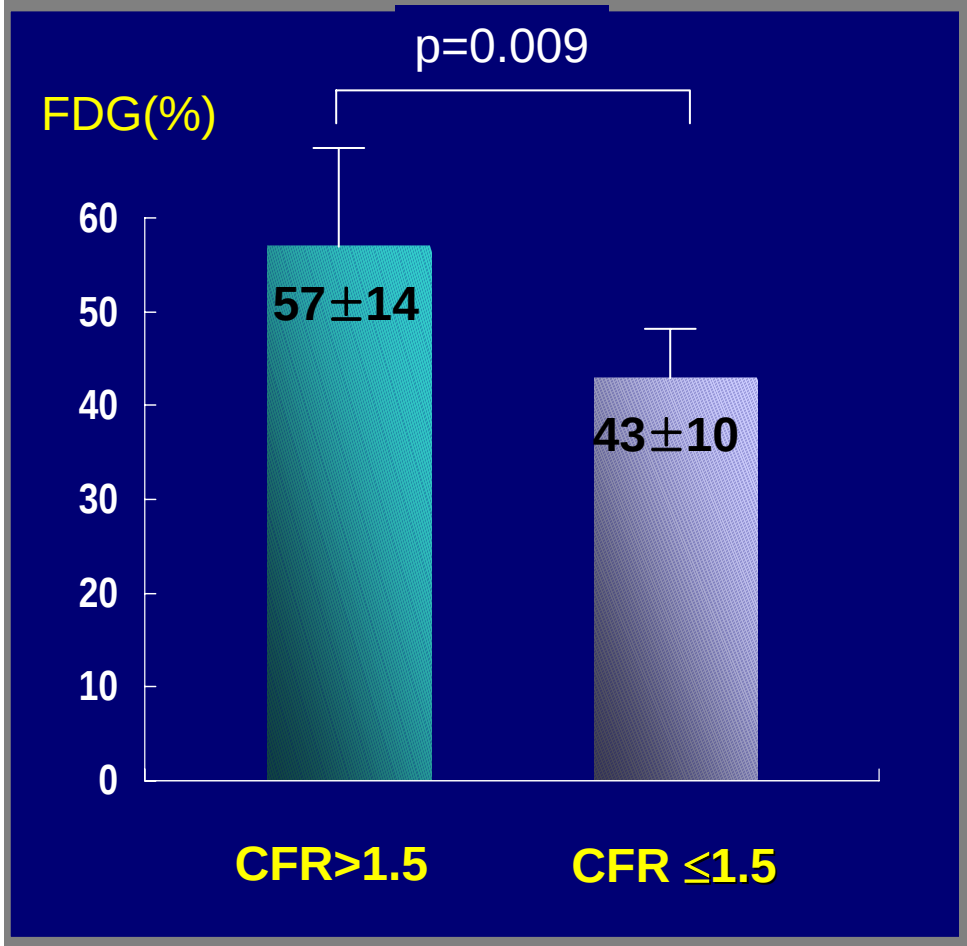
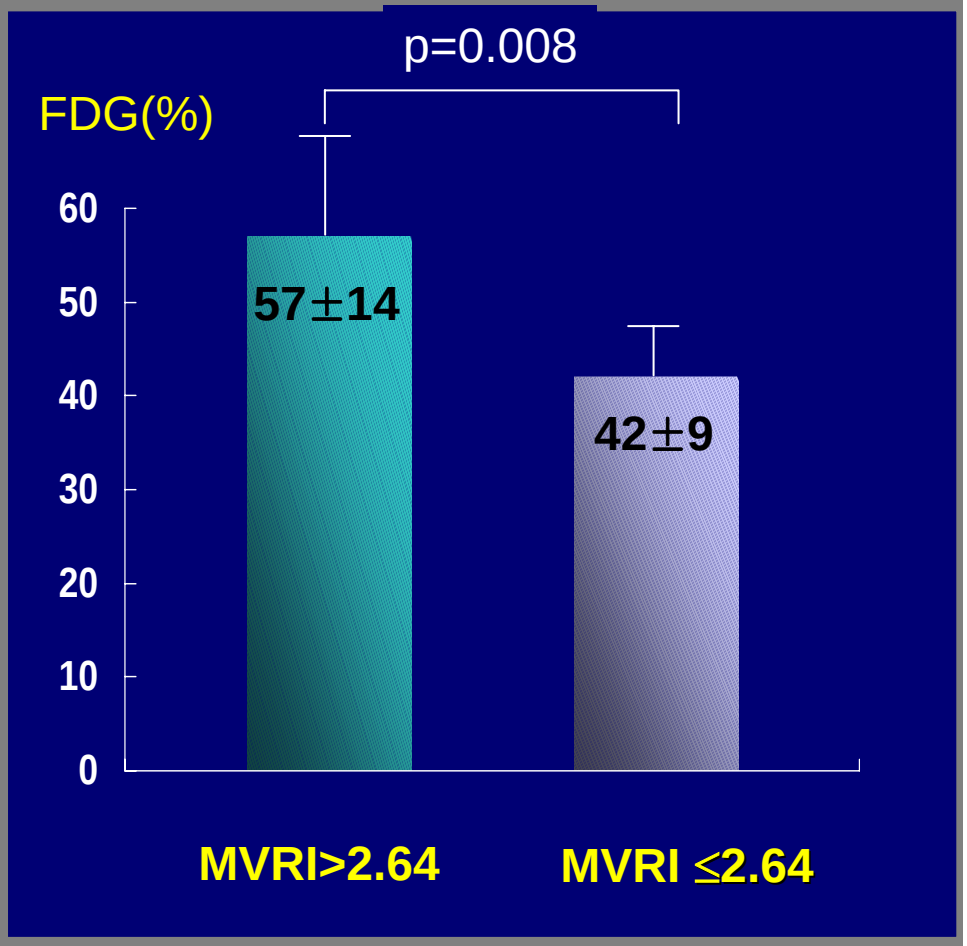
  showed significant correlations with myocardial viability on ^{18}F-FDG PET imaging, and should be considered as important prognostic factors.

- Simply assess myocardial viability and prognosis with a little longer final angiography after primary PCI !

Degree of FDG-Uptake Physiologic Parameters





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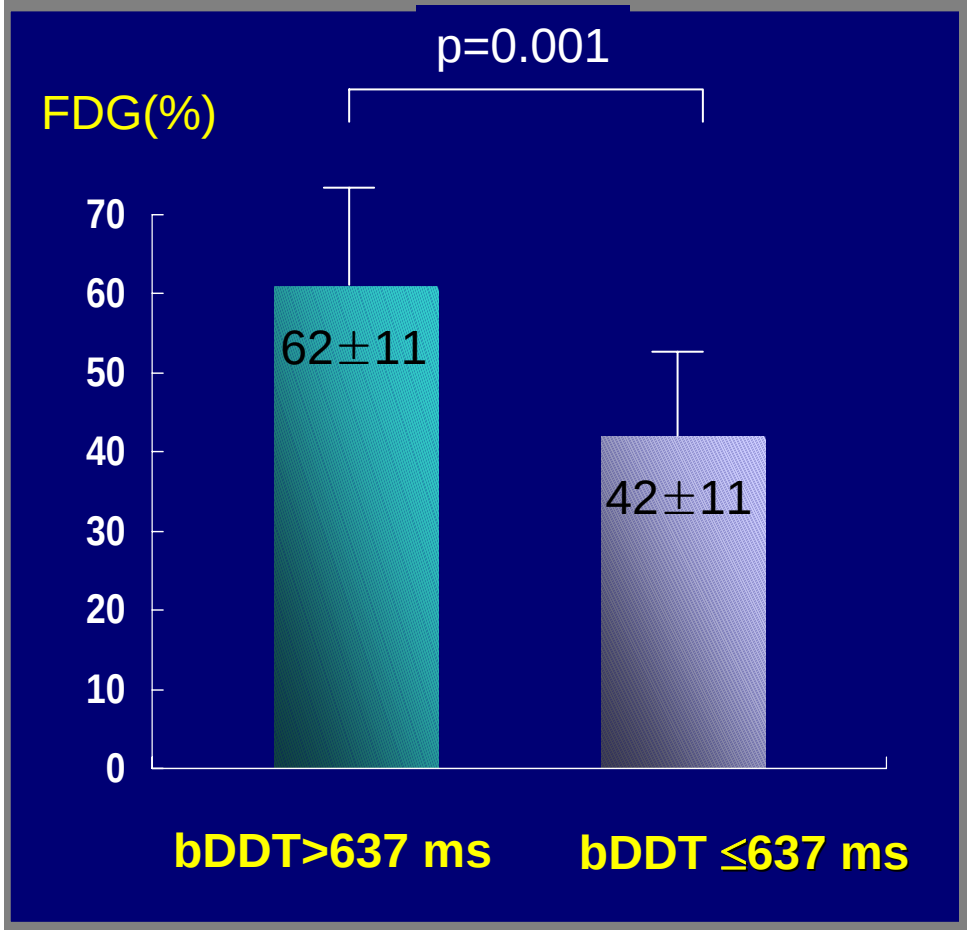
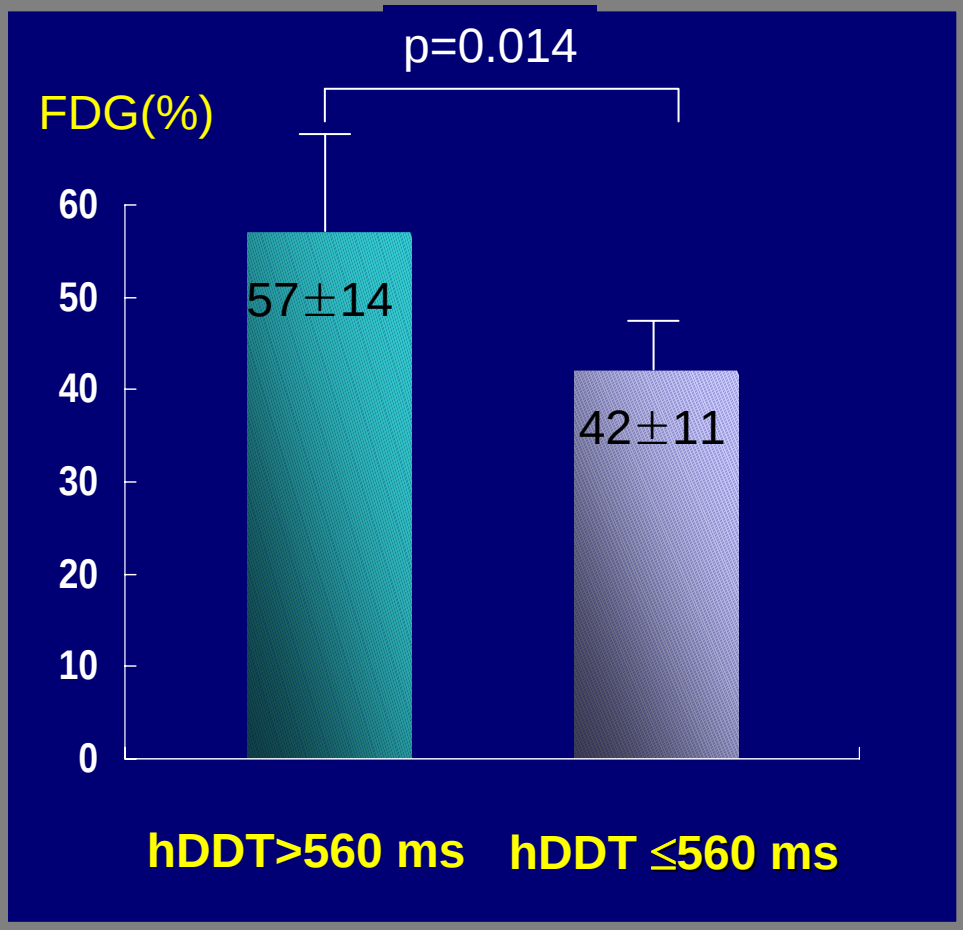
Physiologic Parameters





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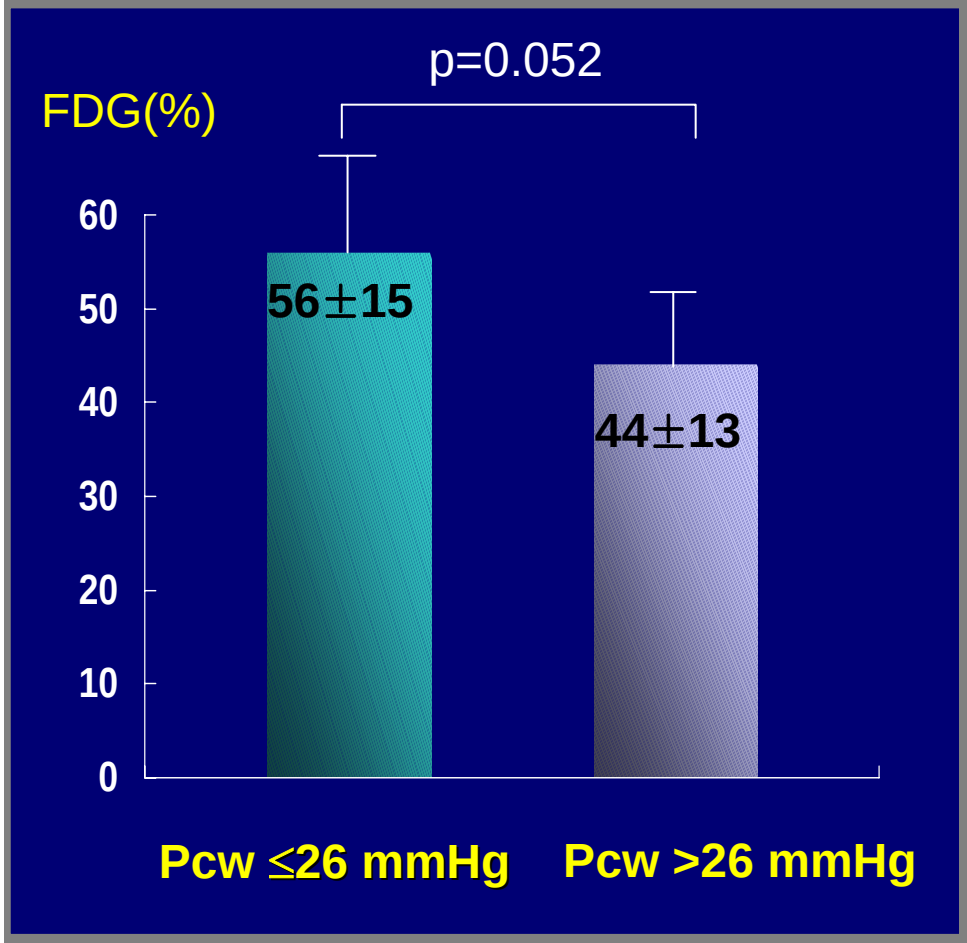

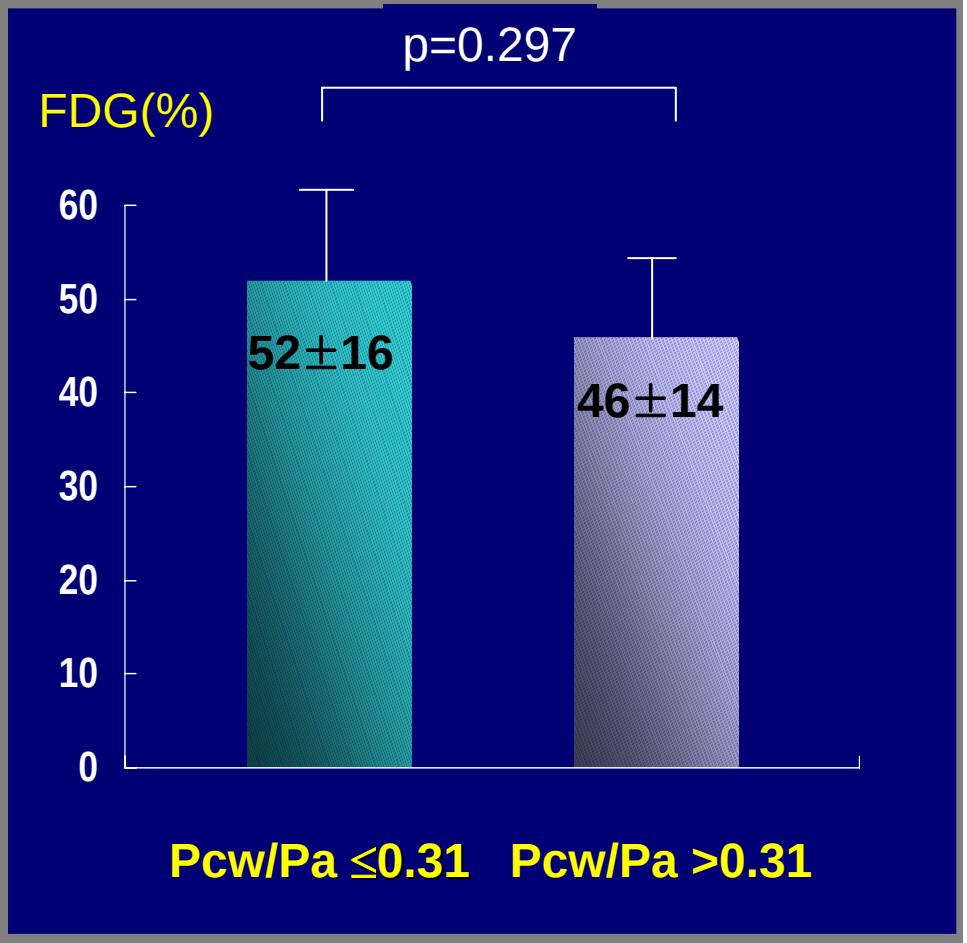

PET Imaging

- Discovery ST, Combined PET and CT Scan, GE medical system, USA
- PET imaging was performed 1 week after PCI by routine protocol.
- 50 g of oral glucose(50% Dextrose solution 100cc) are given 1 hour before FDG(^{18}F-Fluorodeoxyglucose) injection.
- 30 minutes after FDG 370 MBq(10 mCi) injection PET/CT images obtained.
- Perfusion and FDG images are analyzed by quantitative activity profile analysis similar to that used in SPECT image processing.
- %FDG was obtained from dividing the summed %FDG perfusion scores in the risk area by the number of segments of infarct territory.

Viability on PET
TIMI Epicardial Flow

		Viable	Non-Viable	P-value
Pre PCI TIMI	0~1	3 (27.3)	11 (73.4)	0.062
	2	5 (45.4)	2 (13.3)	
	3	3 (27.3)	2 (13.3)	
		11	15	
Post PCI TIMI	0~1	0 (0)	0 (0)	0.053
	2	0 (0)	5 (33.3)	
	3	11 (100)	11 (66.7)	
		11	15	

Viability on PET
TIMI Myocardial Perfusion Grades

		Viable	Non-Viable	P-value
Pre PCI TMPG	0~1	4 (57.1)	7 (100)	0.148
	2	1 (14.3)	0 (0)	
	3	2 (28.6)	0 (0)	
		7	7	
Post PCI TMPG	0~1	0 (0)	7 (46.7)	<0.001
	2	1 (9.1)	6 (40.0)	
	3	10 (90.9)	2 (13.3)	
		11	15	