SPECT AND PET: HOW USEFUL FOR PCI PATIENTS

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Nuclear Imaging: SPECT and PET

- Before PCI
  - Culprit vessel identification
  - Viability study
- After PCI
  - Restenosis detection

Role of SPECT before PCI

- Documenting ischemia
- Determining the functional impact of the lesion
  - Stratify risk in 25-75% stenosis
- Identifying the lesion responsible for the ischemic symptom: 'Culprit lesion' (>80%)
- Selection of patients to perform PCI
  - Based on CAG alone vs. considering of ischemia
  - No ischemia → low risk

Cardiac Image Fusion from Stand-Alone SPECT and CT: Clinical Experience

Supplying vessel
Perfusion defect

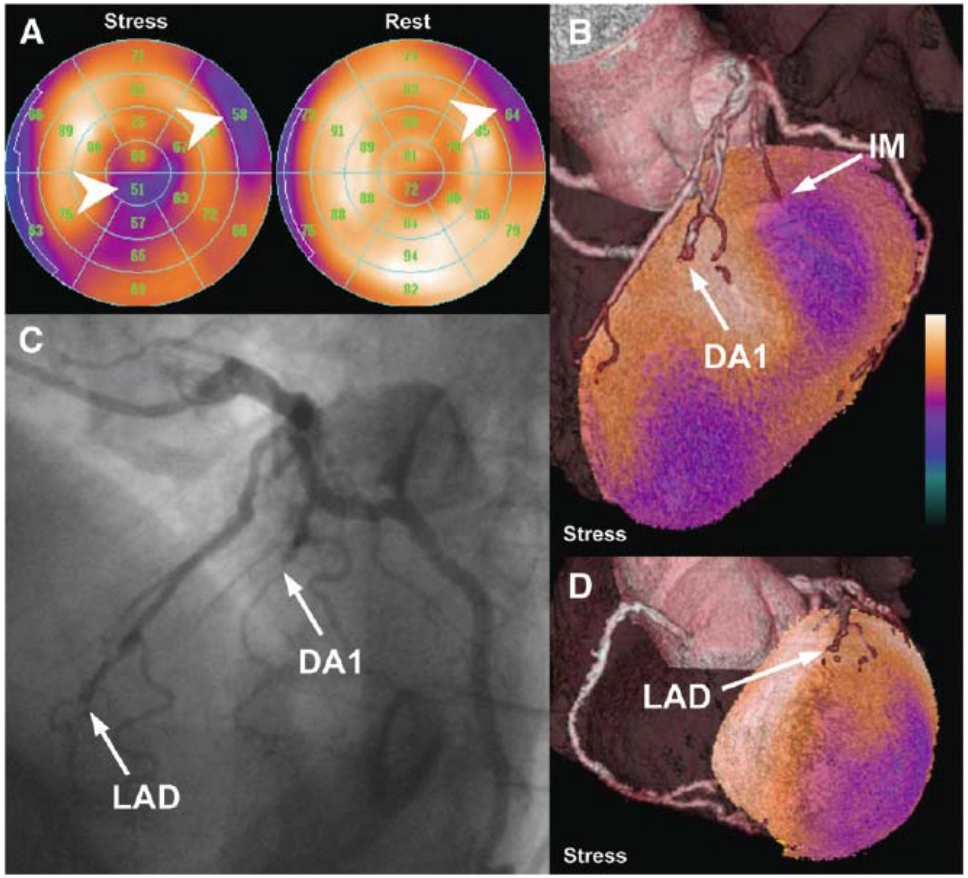


FIGURE 2. (A) Stress and rest perfusion polar maps of SPECT-MPI study show mixed basal anterolateral defect and reversible inferoapical perfusion defect (arrowheads). (B and D) Fused SPECT/CT images reveal total occlusion of LAD and subtotal occlusion of first diagonal branch (DA1), which are confirmed by conventional CA (C). Anterolateral perfusion defect is caused by lesion of partially calcified small intermediary branch (IM); however, this vessel is not well visualized by CA.

Anterolateral defect by intermediary a. stenosis

J Nucl Med 2007; 48:696–703

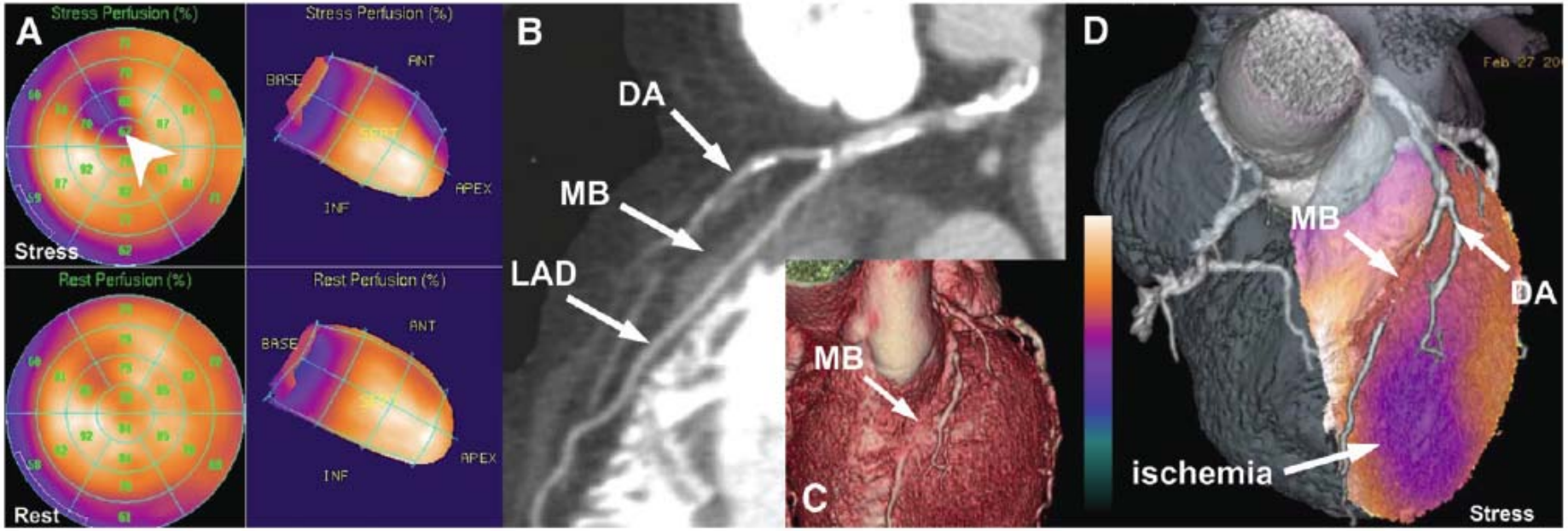


FIGURE 3. (A) Perfusion polar maps at stress (dobutamine stress) and rest show reversible anteroseptal perfusion defect. (B and C) 64-slice CTA revealed myocardial bridging (MB) of mid LAD of >2-cm length and calcified plaque at origin of first diagonal branch (DA). (D) Fused 3D SPECT/CT images could allocate reversible perfusion defect to DA, whereas MB seemed to be hemodynamically insignificant.

Anteroseptum defect-diagonal branch
Myocardial bridging-insignificant

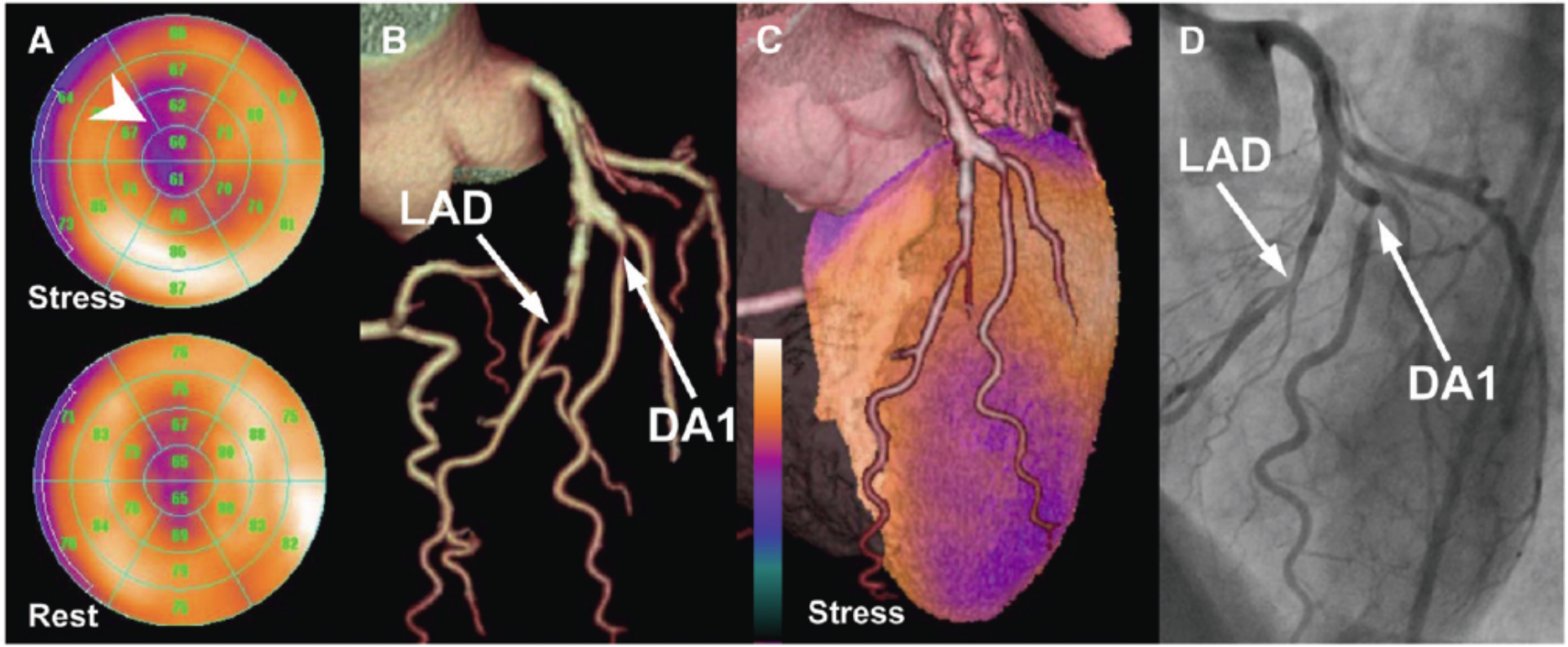


FIGURE 4. (A) Perfusion polar maps of SPECT-MPI at stress and rest show largely reversible anteroapical perfusion defect (arrowhead). (B) 3D volume-rendered CTA images show coronary vessel tree with stenosis of mid LAD and proximal stenosis of first diagonal branch (DA1). (C) Fused 3D SPECT/CT images are able to identify DA1 stenosis as functionally relevant lesions. (D) Findings were confirmed by invasive CA.

Apical anterior wall defect
Stenosis in mid LAD and diagonal branch

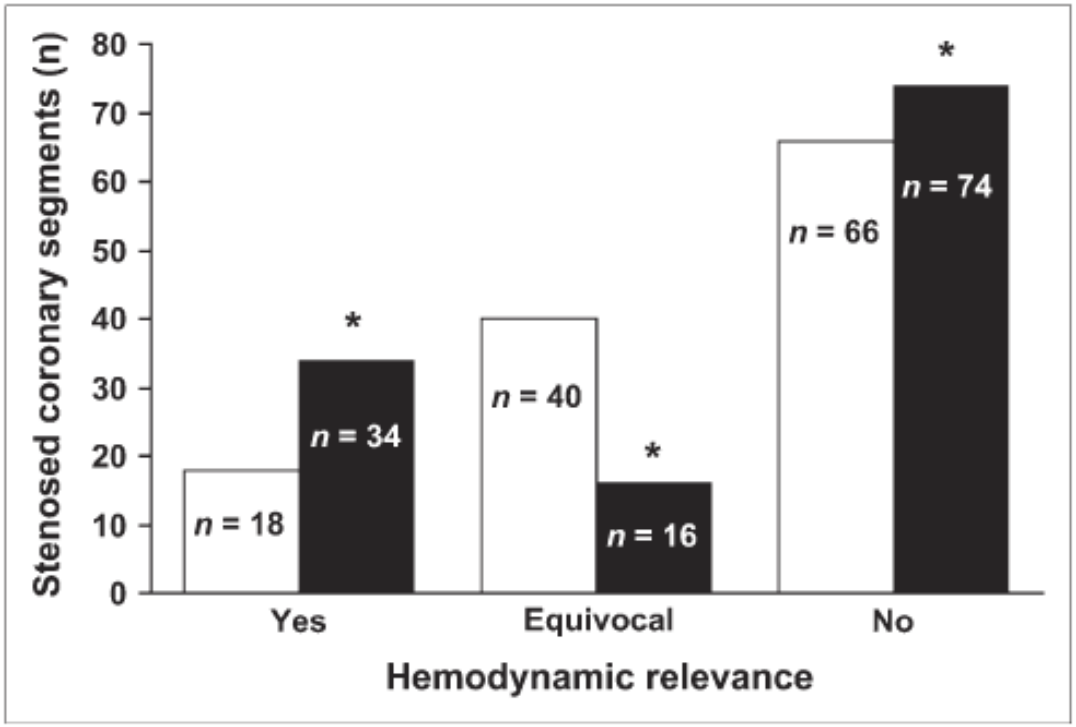
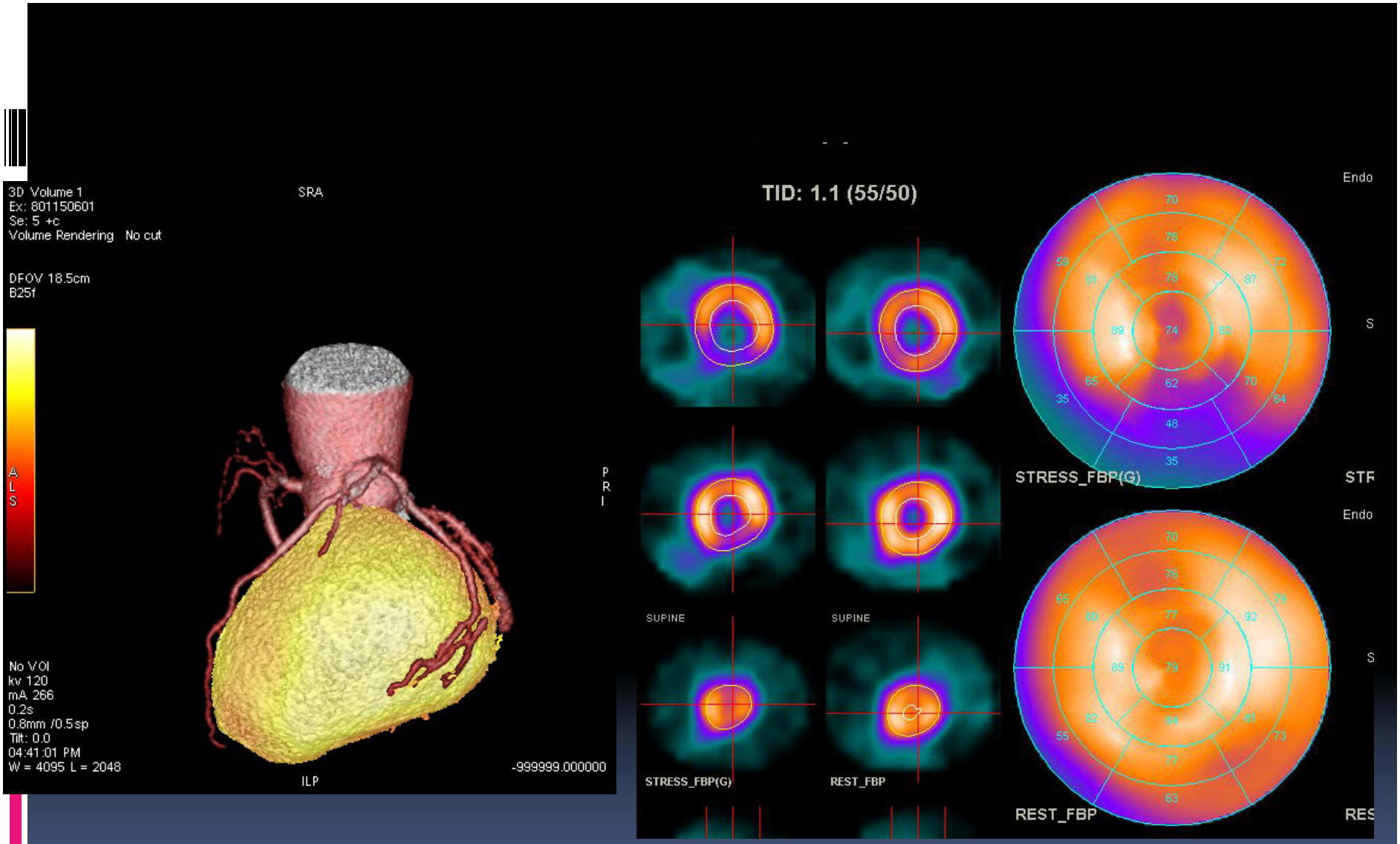


FIGURE 1. Interpretation of stenosed coronary segments with regard to hemodynamic significance on side-by-side (white columns) or fused (black columns) analysis. *$P < 0.001$ for comparison of fused vs. side-by-side analysis (χ^2 test).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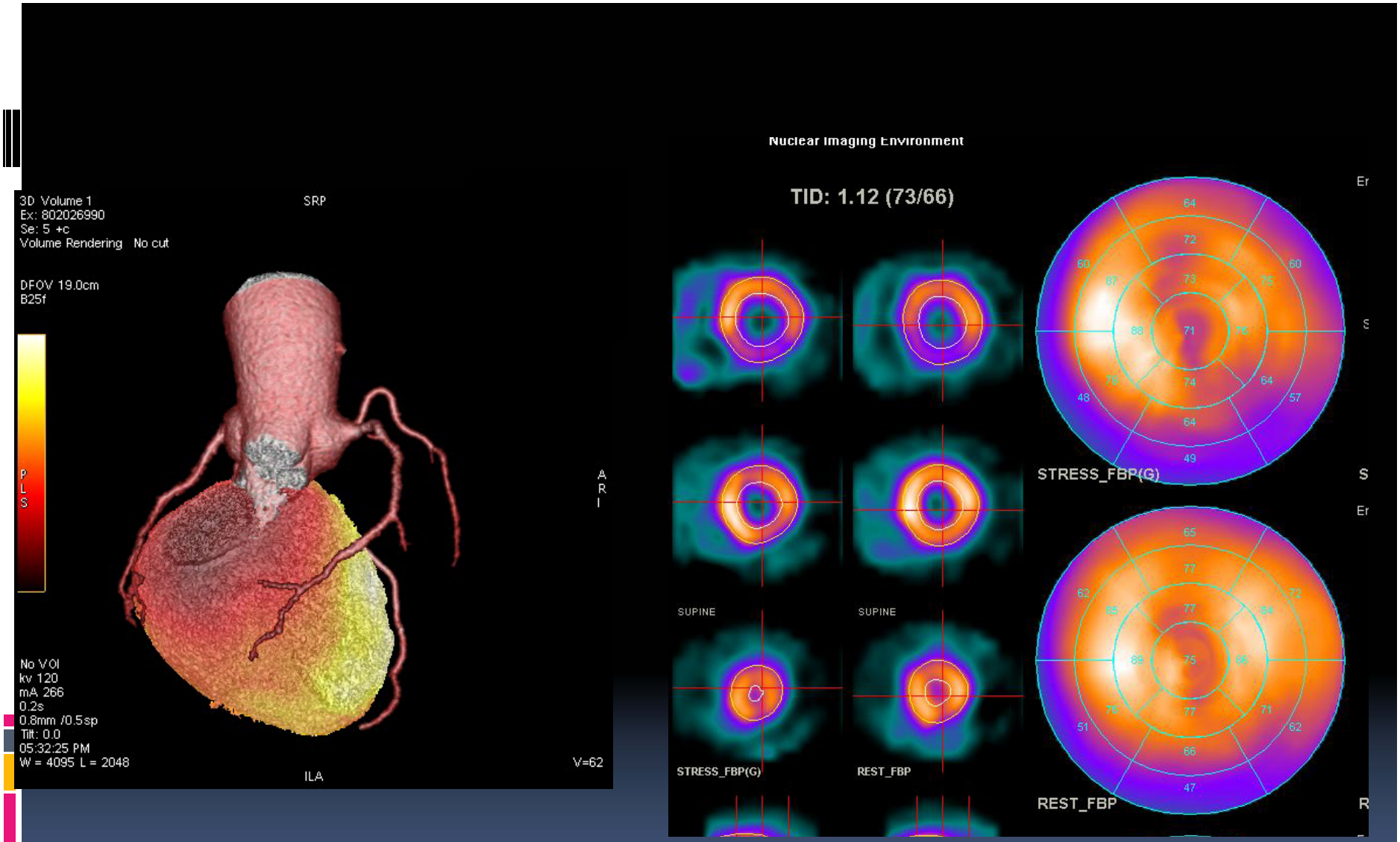
Ex: 801150601
Se: 5 +c
Volume Rendering No cut
DFOV 18.5cm
B25f
SRA
A
L
S
No VOI
kv 120
mA 266
0.2s
0.8mm /0.5sp
Tilt: 0.0
04:41:01 PM
W = 4095 L = 2048
ILP
-999999.000000
P
R
I
TID: 1.1 (55/50)
SUPINE
SUPINE
STRESS_FBP(G)
REST_FBP
Endo
STRESS_FBP(G)
Endo
REST_FBP

RCA



Anterior wall, inferolateral wall
LAD diagonal, LCX

Nuclear imaging for viability

- Preserved cell membrane integrity
  - Thallium
  - MIBI, tetrofosmin
- Preserved cell metabolism
  - FDG (glucose)

Frequency of viable myocardium

Table 1 Incidence of viable myocardium in patients with ischaemic left ventricular dysfunction

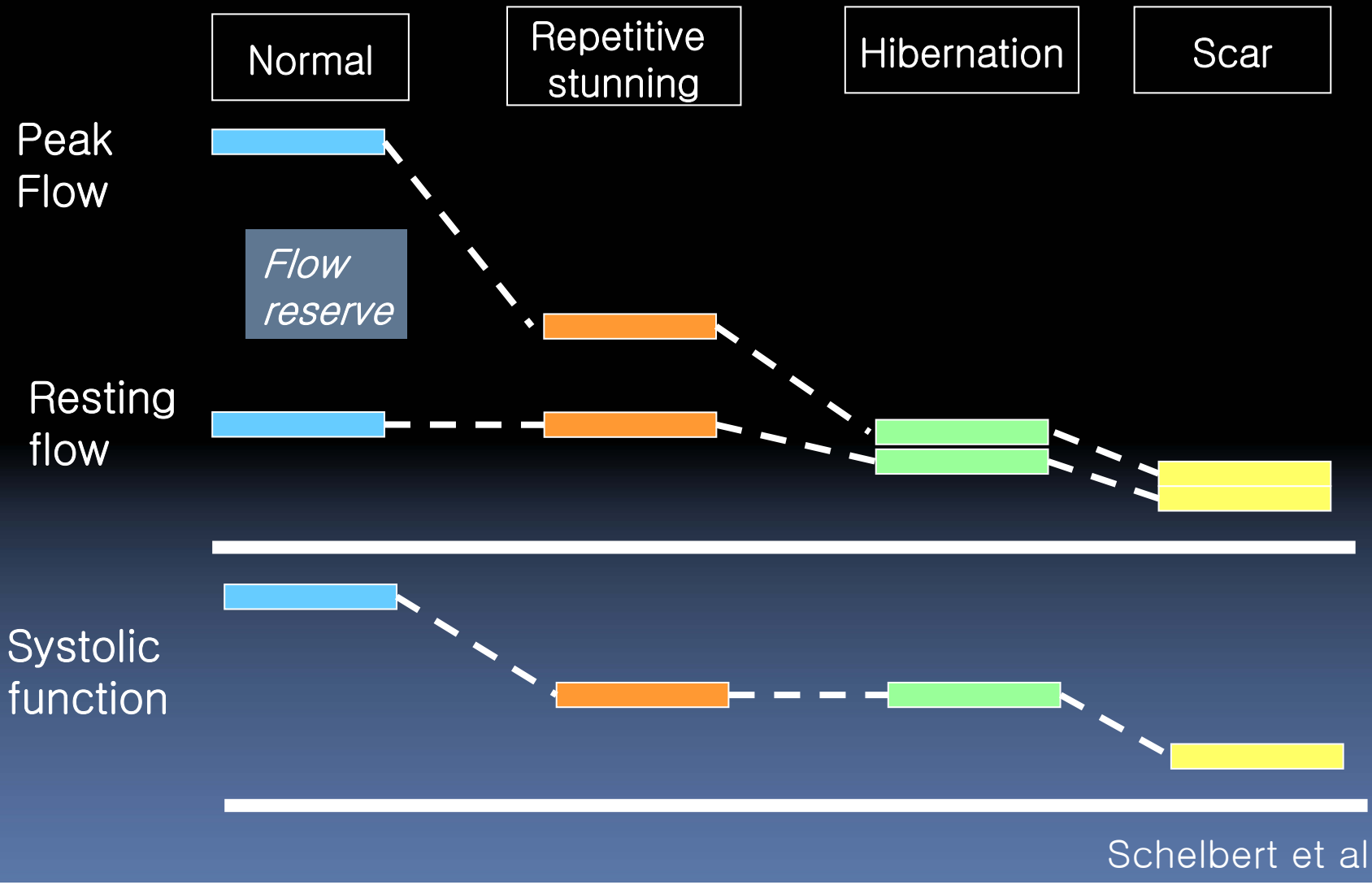
Author	Number of patients	LVEF	Viability technique	Incidence of viability
Auerbach[77]	283	26 (8%)	FDG/N13 ammonia PET	55%
Al-Mohammed[78]	27	19 (6%)	FDG/N13 ammonia PET	52%
Schinkel[79]	104	25 (7%)	FDG/Tc-99m TF SPECT	61%
Fox[80]	27	NA	Tc-99m MIBI/TF SPECT	37%

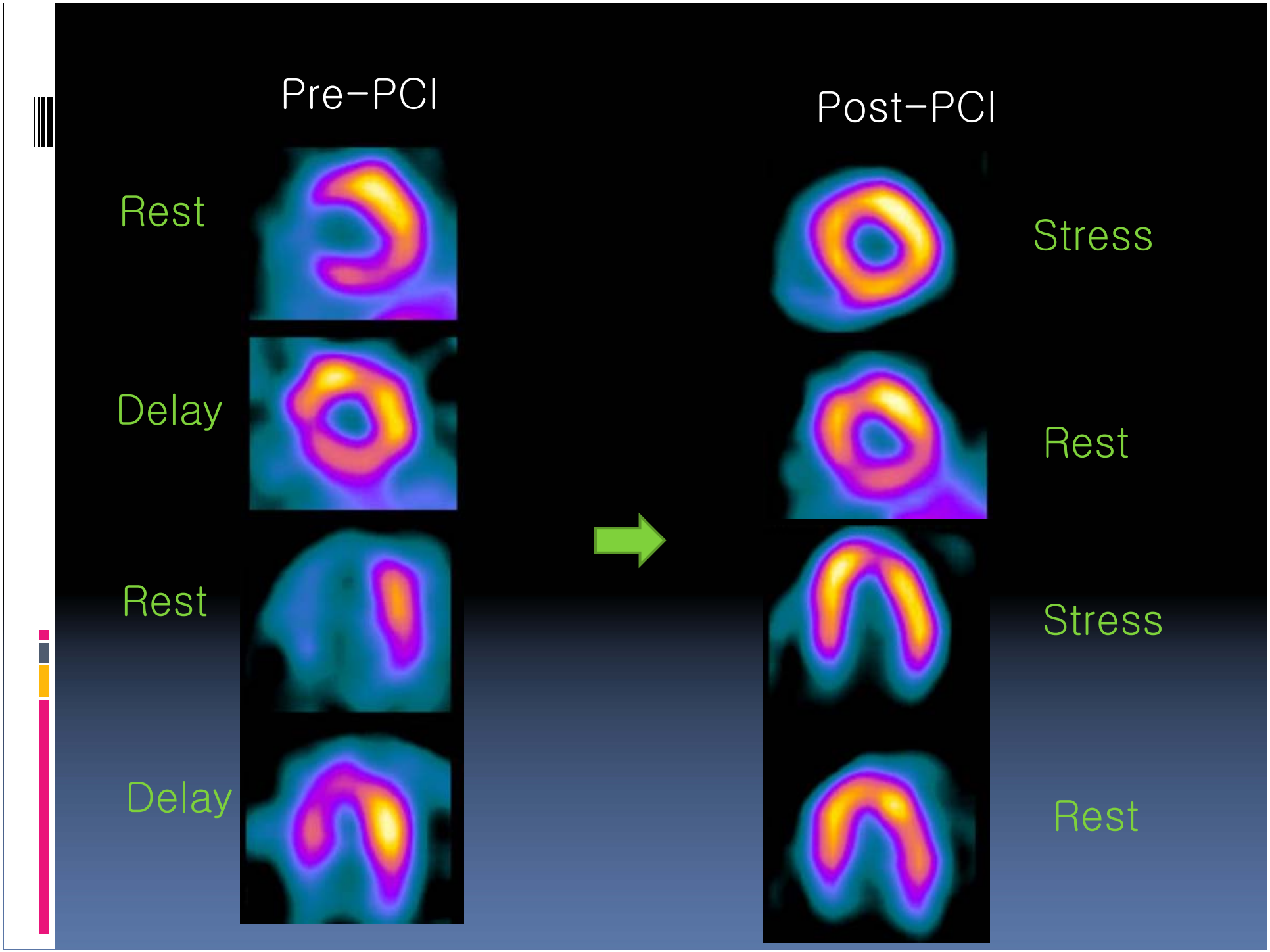
FDG, F18-fluorodeoxyglucose; LVEF, left ventricular ejection fraction; MIBI, sestamibi; PET, positron emission tomography; SPECT, single photon emission computed tomography; Tc-99m, technetium-99m; TF, tetrofosmin.

About 50%

Bax JJ, Heart 2004;90(Suppl V):v26–v33.

Pathophysiology of ischemic LV dysfunction

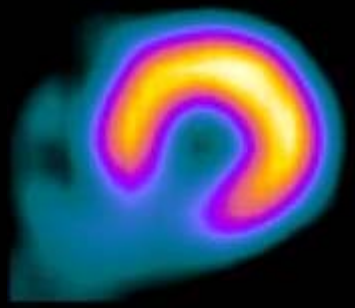



Pre-PCI
Post-PCI
Rest
Delay
Rest
Delay
Stress
Rest
Stress
Rest

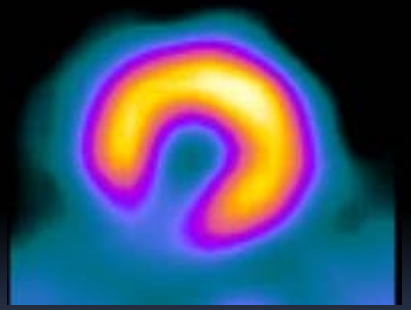
Pre-PCI

Post-PCI

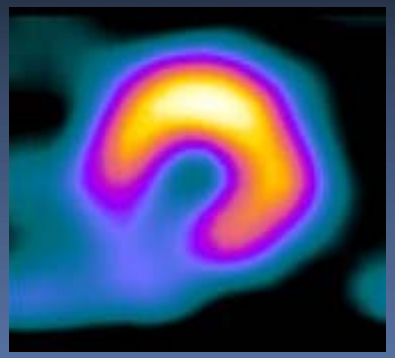
Stress



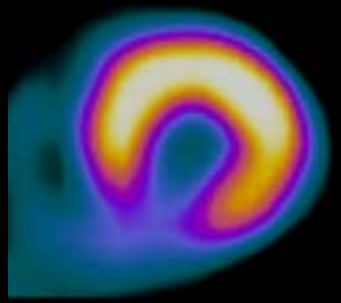
Rest



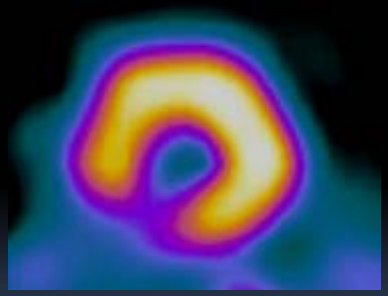
Delay



Stress



Rest



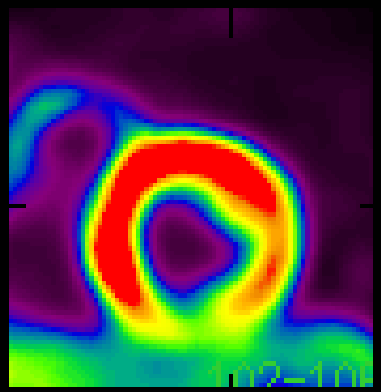
PET patterns of myocardial viability assessment

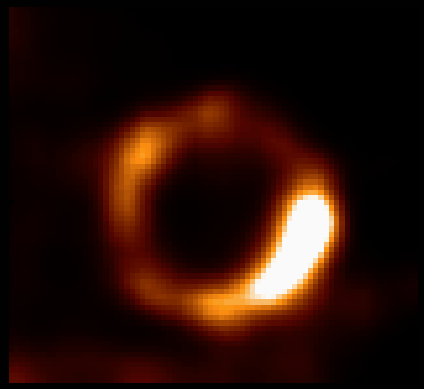
	Rest perfusion	Stress perfusion	Rest FDG
Transmural MI	↓↓↓	↓↓↓	↓↓↓
Non-transmural MI	↓, ↓↓	No change or further decrease	↓, ↓↓
Hibernation	↓ or ↓↓↓	No change or further decrease	normal
Repetitive stunning	normal	Further decrease	normal

NH_3 PET

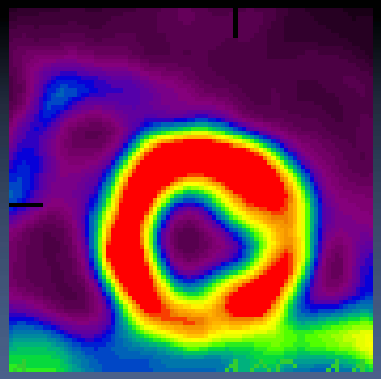
FDG PET

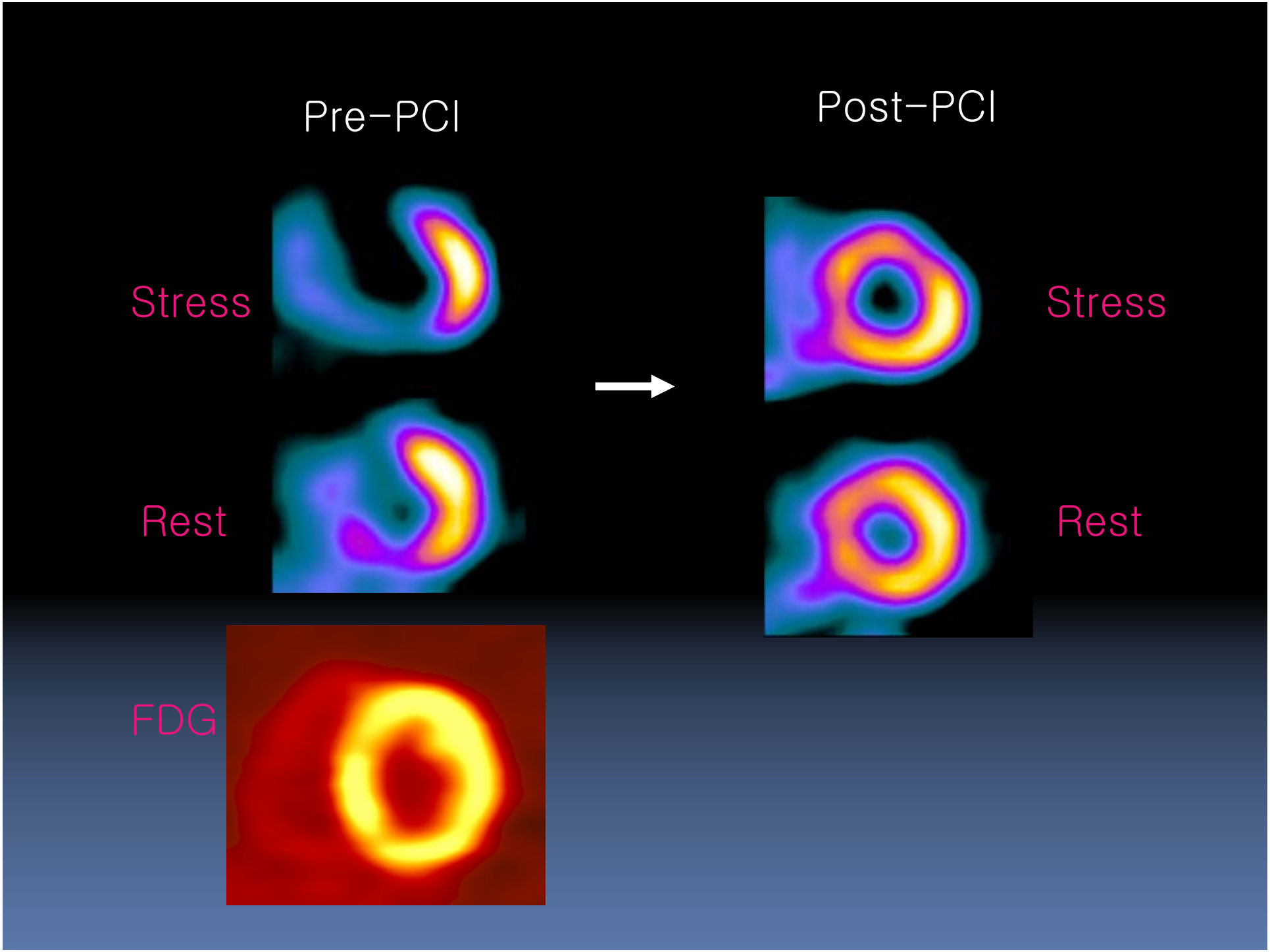
Stress

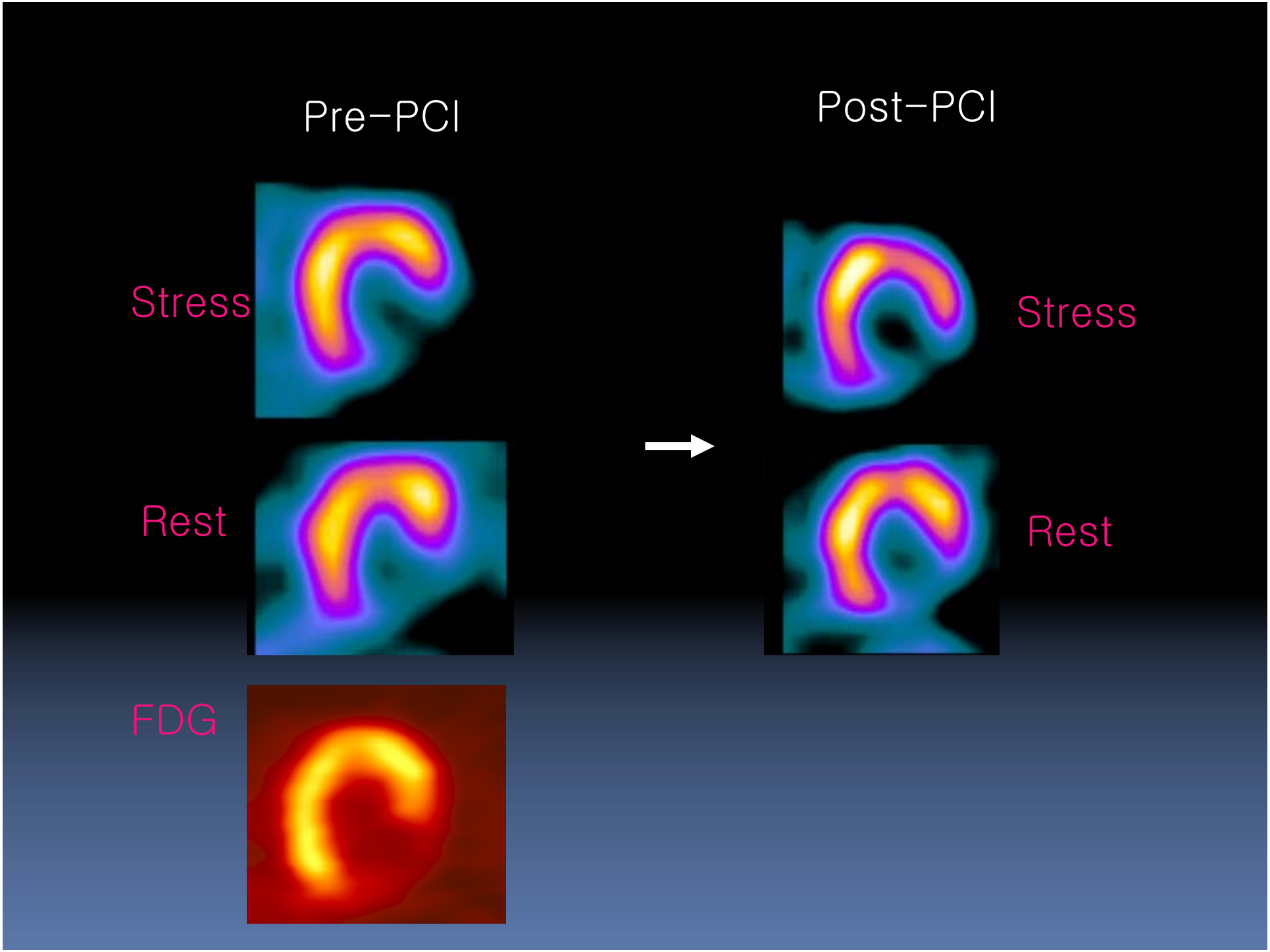




Rest

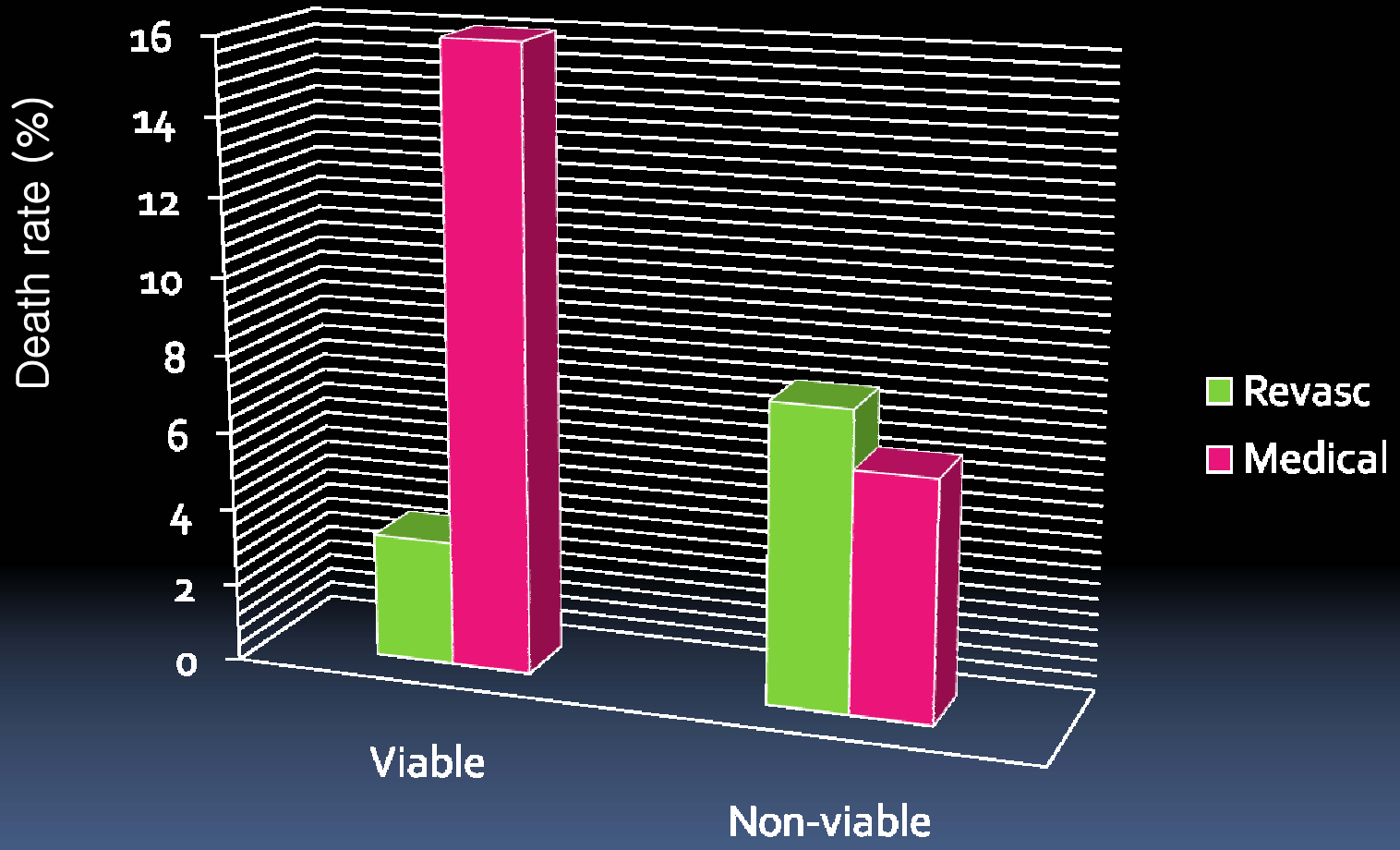



Pre-PCI
Post-PCI
Stress
Rest
Stress
Rest
FDG


Pre-PCI
Post-PCI
Stress
Rest
FDG
Stress
Rest

Viability and outcome

Meta-analysis of 24 studies(3088 patients)



Allman KC, JACC 2002

Following PCI

MPI after PCI

- Symptom: unreliable index of restenosis
- MPI after PCI: 3-12 months after PCI
  - Sensitivity: 79-89%
- Prognostic value of MPI after PCI (Parisi et al, JACC)
  - Mortality
    - Reversible: 20%
    - Normal or persistent: 7%

Table 4. Accuracy of Myocardial SPECT Imaging Following Percutaneous Coronary Intervention

Author (Ref.)	Year	No. of Patients	PCI Modality	% With Angina	Mean Time to SPECT	Mean Time to Angiogram	Sens %	Spec %	Acc %
Hecht et al. (15)	1991	116	PTCA	65	6 months	1 week	93	77	86
		41*		0			96*	75*	88*
		75†		100			91†	77†	85†
Marie et al. (37)	1993	62*	PTCA	0	6 months	3 days	94*	84*	87*
Milan et al. (54)‡	1996	37	PTCA	N/A	"late"	1 month	88	78	83
		20§					92§	67§	N/A
Kósa et al. (55)	1998	82 (99)	Stenting	N/A	7 months	1 month	79	78	79
		35 (52)§		N/A			100§	82§	85§
Milavetz et al. (56)	1998	33	Stenting	64	3 months	5 days	71‖	—	67‖
							95¶	73¶	88¶
Caner et al. (57)#	1998	34 (37)	PTCA	N/A	2–48 months	1 month	76	79	78
Beygui et al. (58)	2000	179 (208)*	PTCA	0	6 months	7 days	63*	77*	71*
		111 (138)					56§	81§	74§
Galassi et al. (59)	2000	97 (107)	Stenting	N/A	4 months	2 months	82**	84**	83**
		46 (56)§					76§	95§	89§
Overall performance of SPECT MPI							79††	79††	79††

Number of treated territories are indicated in parentheses; restenosis is defined as ≥50% diameter stenosis unless otherwise indicated; *patients with "silent" ischemia; †patients with "symptomatic" ischemia; ‡all patients referred because of "equivocal" exercise stress tests, values reported are for qualitative analyses; §patients without prior infarction; ‖calculations using ≥50% cross-sectional area narrowing definition; ¶calculations using ≥70% cross-sectional area narrowing definition; #dobutamine stress used for all patients; **calculations based upon vascular territories; ††weighted average.

MPI = myocardial perfusion imaging; PCI = percutaneous coronary intervention; SPECT = single-photon emission computed tomography. Other abbreviations as in Tables 1 and 3.

Giedd KN et al, JACC 2003

6 month SPECT after PCI

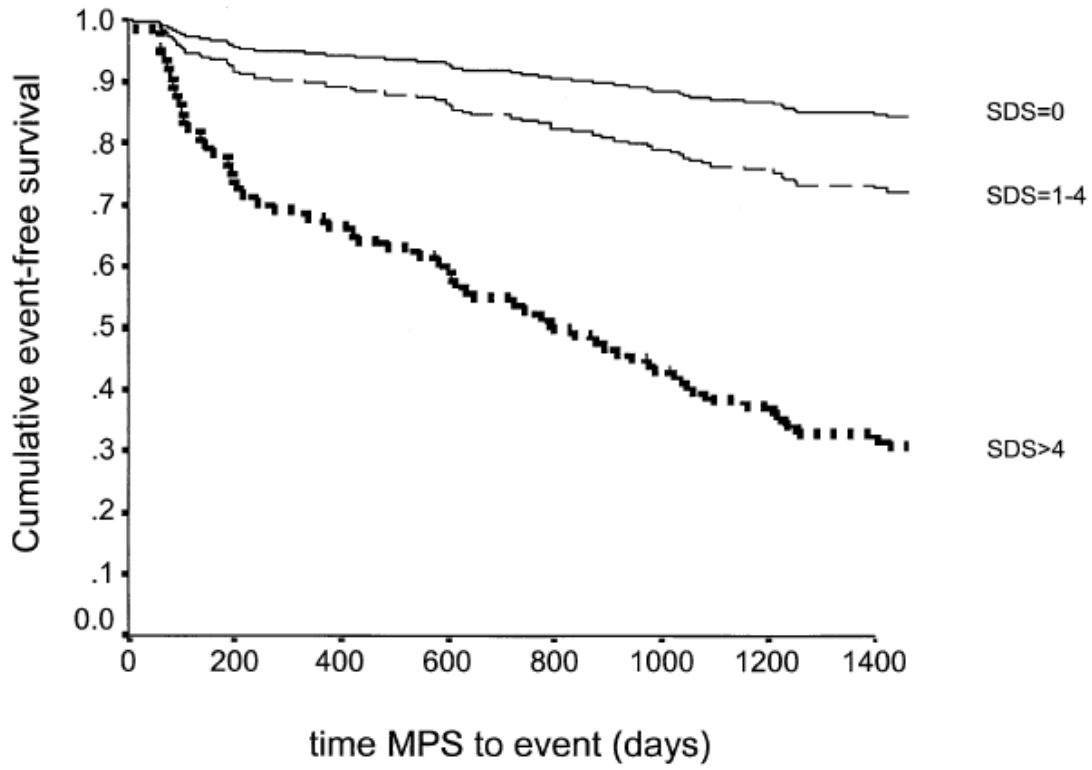


Figure 3. Kaplan-Meier event-free survival curves by summed difference score (SDS) categories. Patients with an SDS of 0 (n = 242) had significantly lower event rates than patients with an SDS of 1 to 4 (n = 49; p = 0.03); these patients had significantly lower event rates than patients with SDS >4 (n = 16; p = 0.005). Note the significant differences in outcome between patients with no, mild, and moderate to severe ischemia, as defined by SDS. MPS = myocardial perfusion SPECT.

Zellweger MJ et al. 2003 JACC

Residual ischemia (SDS) – prognostic value following PCI

Conclusion

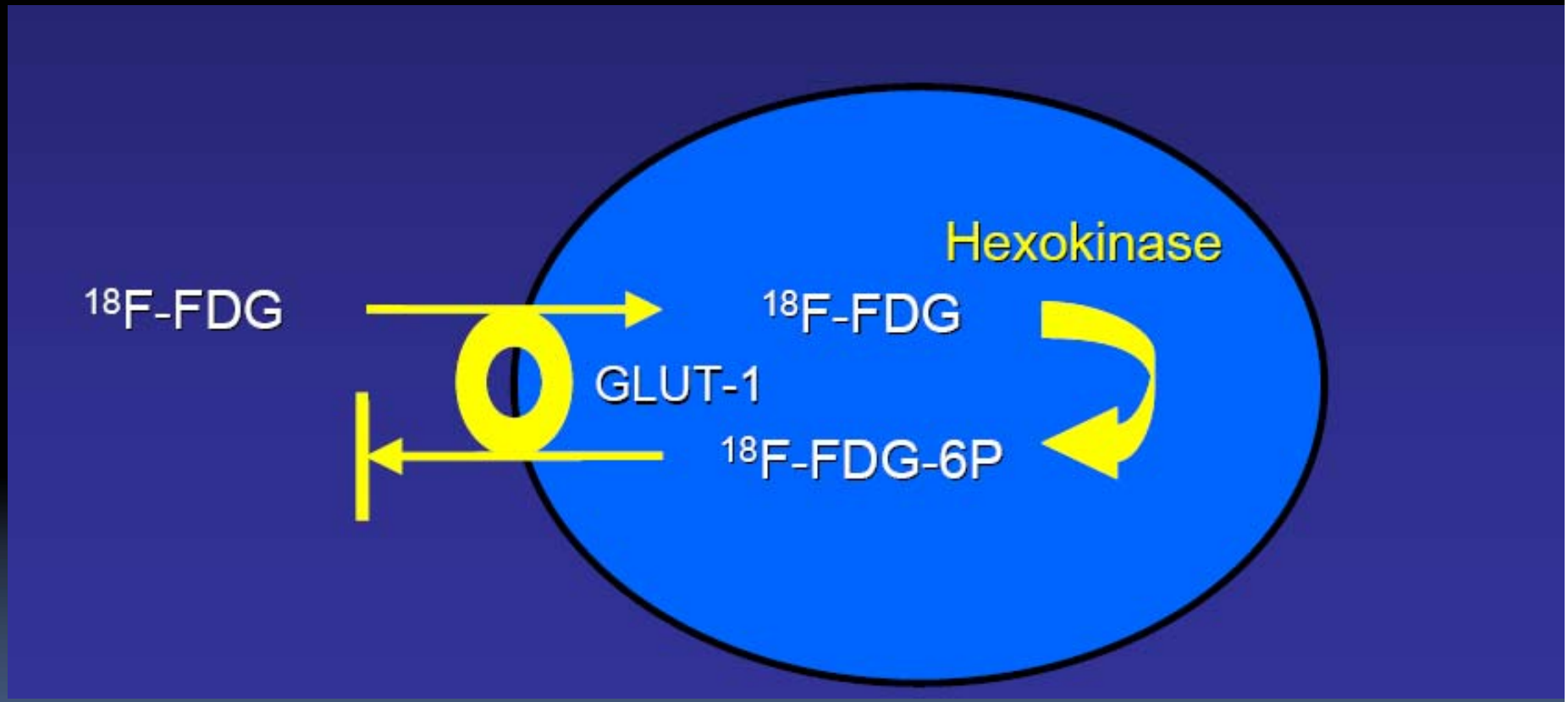
- Fusion software
  - Detecting ischemia
  - Culprit vessel
  - Restenosis
- Viability
  - Perfusion-metabolism mismatch

- Thank you for your attention!

Advantages of nuclear imaging

- Myocardial perfusion (stress/rest)
  - Quantitative analysis
  - Accurate
  - Reproducible
- Myocardial metabolism

FDG



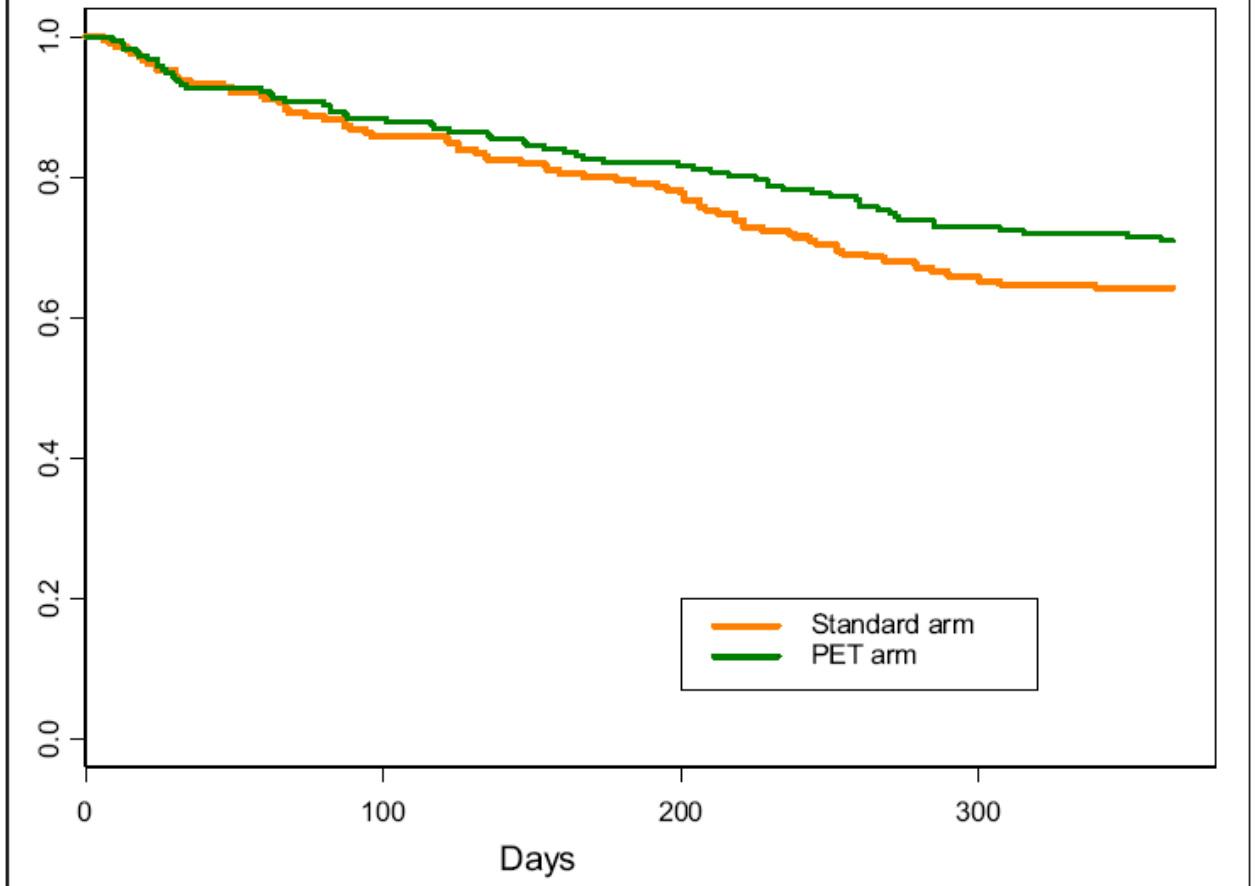


Figure 3 **"Survival Curves" (on the Basis of Time to First Occurring Outcome of the Composite Event)**

Beanlands et al 2007 JACC

Summary in following PCI

- < 3 months:
  - high false-positive
  - Limited role
- 3-6 months
  - Normal MPI exclude restenosis
  - Abnormal MPI → angiography
- > 6 months
  - Accurate to diagnose retenosis

Why viability study?

- Morbidity and mortality of revascularization with low EF remain high
  - Need to determine risk vs. benefit
- Revascularization helps low EF with minimal or no angina?

End points for clinical effectiveness

- Improvement of regional LV dysfunction
- Improvement of global LV dysfunction (LVEF)
- Improvement of heart failure symptoms
- Improvement of survival

Characteristics of viable myocardium

Table 2 Characteristics of dysfunctional but viable myocardium

Characteristic	Imaging modality	Markers of viability
Perfusion/intact cell membrane	Thallium-201 SPECT	Tracer activity >50% Redistribution >10%
Perfusion/intact mitochondria	Technetium-99m TF/MIBI SPECT	Tracer activity >50% Improved tracer uptake after nitrates
Glucose metabolism	FDG imaging (PET or SPECT)	Tracer activity >50% Preserved perfusion/FDG uptake Perfusion-metabolism mismatch
Free fatty acid metabolism	BMIPP SPECT	Tracer activity >50% Perfusion-BMIPP mismatch
Contractile reserve	Dobutamine echo/MRI Dobutamine gated SPECT	Improved contraction Infusion of low dose dobutamine

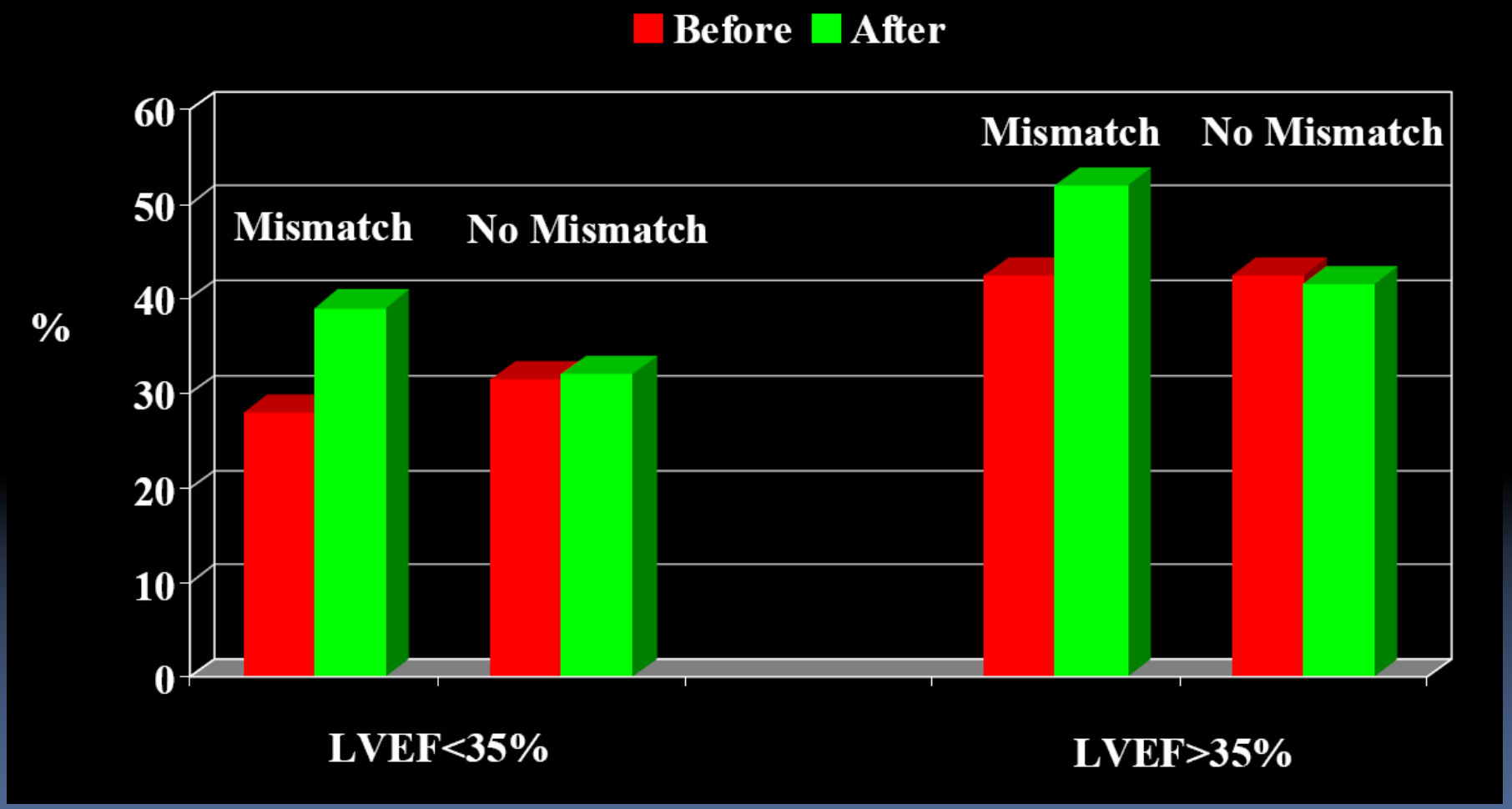
BMIPP, β methyliodophenyl pentadecanoic acid; FDG, F18-fluorodeoxyglucose; MIBI, sestamibi; MRI, magnetic resonance imaging; PET, positron emission tomography; SPECT, single photon emission computed tomography; TF, tetrofosmin.

Bax JJ, Heart 2004;90(Suppl V):v26–v33.

Rest-redistribution Tl-201

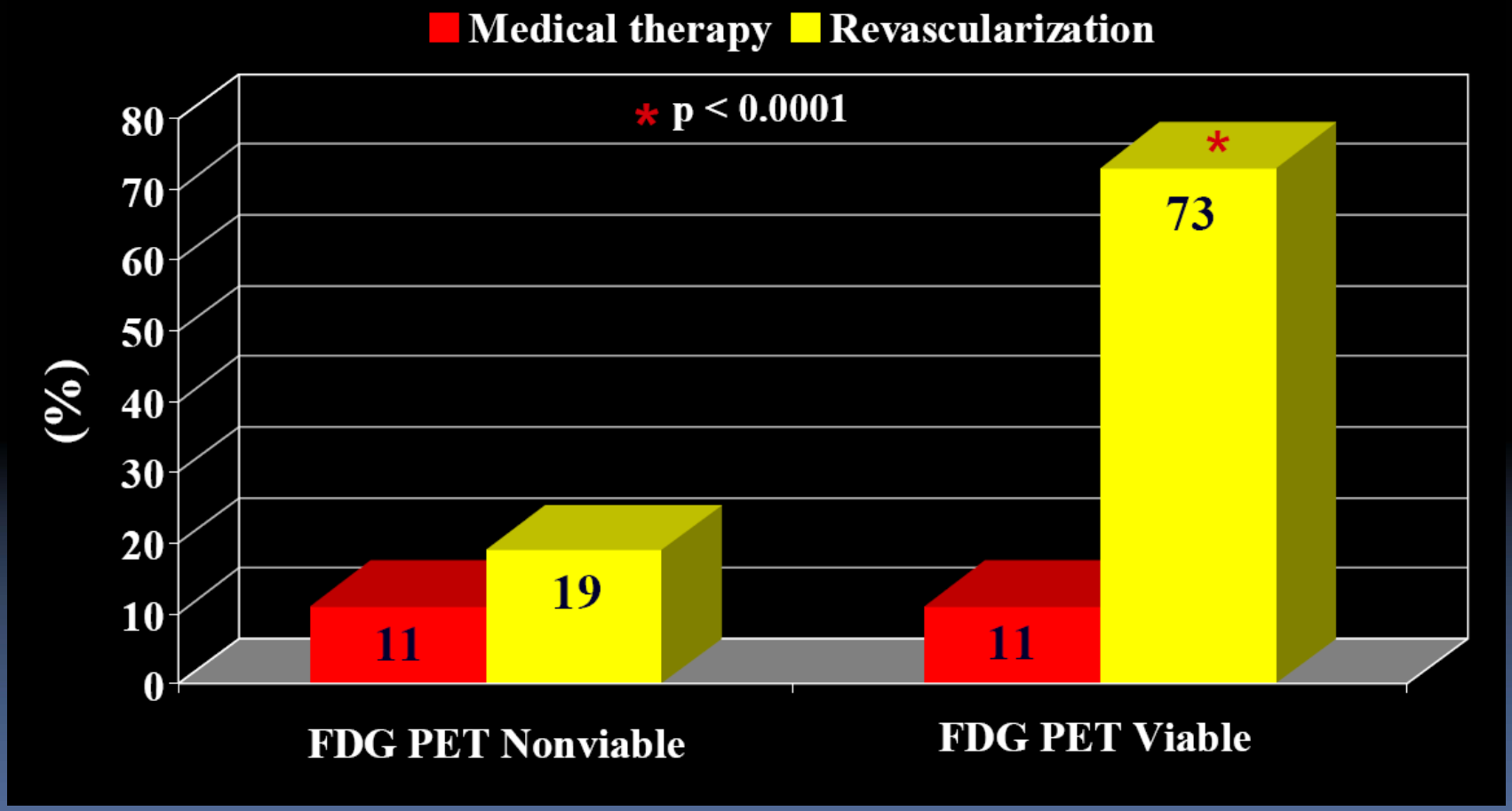
20% enhanced detection of viability by late imaging

PET prediction of post-op LVEF improvement: 25 studies, 772 patients

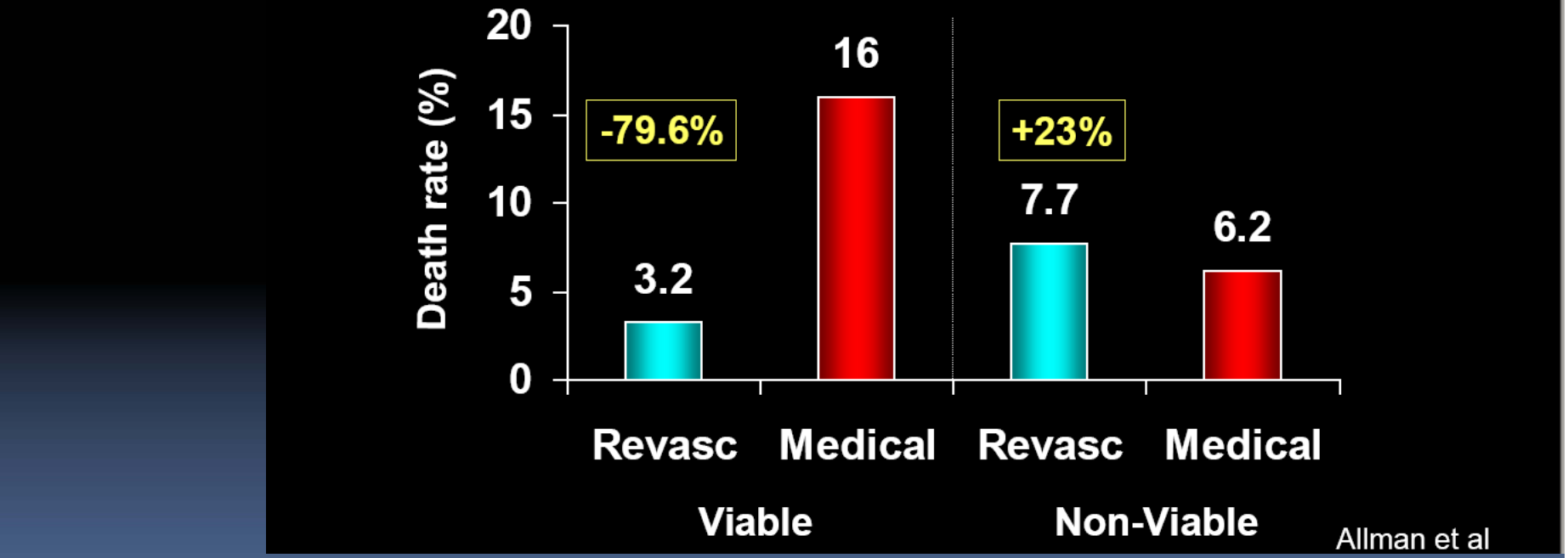


Schelbert HR, Seminars in Nuclear Medicine 2002

Improvement of Heart Failure Symptoms by treatment

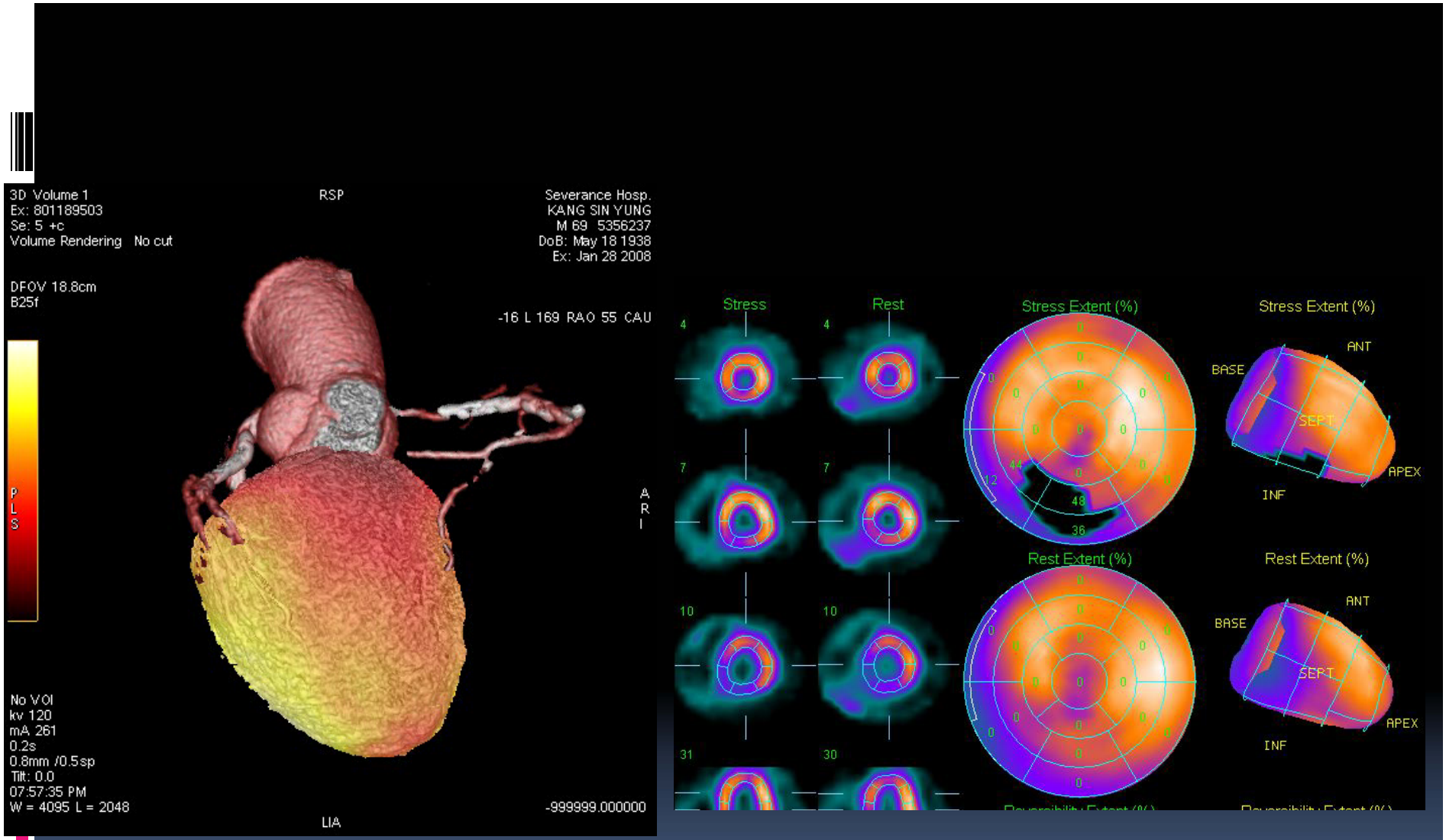


Di Carli, Am J Cardiol 1994


Death rate (%)
20
15
10
5
0
-79.6%
+23%
3.2
16
7.7
6.2
Revasc
Medical
Revasc
Medical
Viable
Non-Viable
Allman et al

After PCI

- Restenosis
  - 1/3 of patients
  - 1/2 of restenosis: asymptomatic
  - 45% of chest pain: no stenosis
- Disease progression
  - 7% per year
- Annual risk of a major adverse cardiac events following PCI: 5-7%



RCA proximal

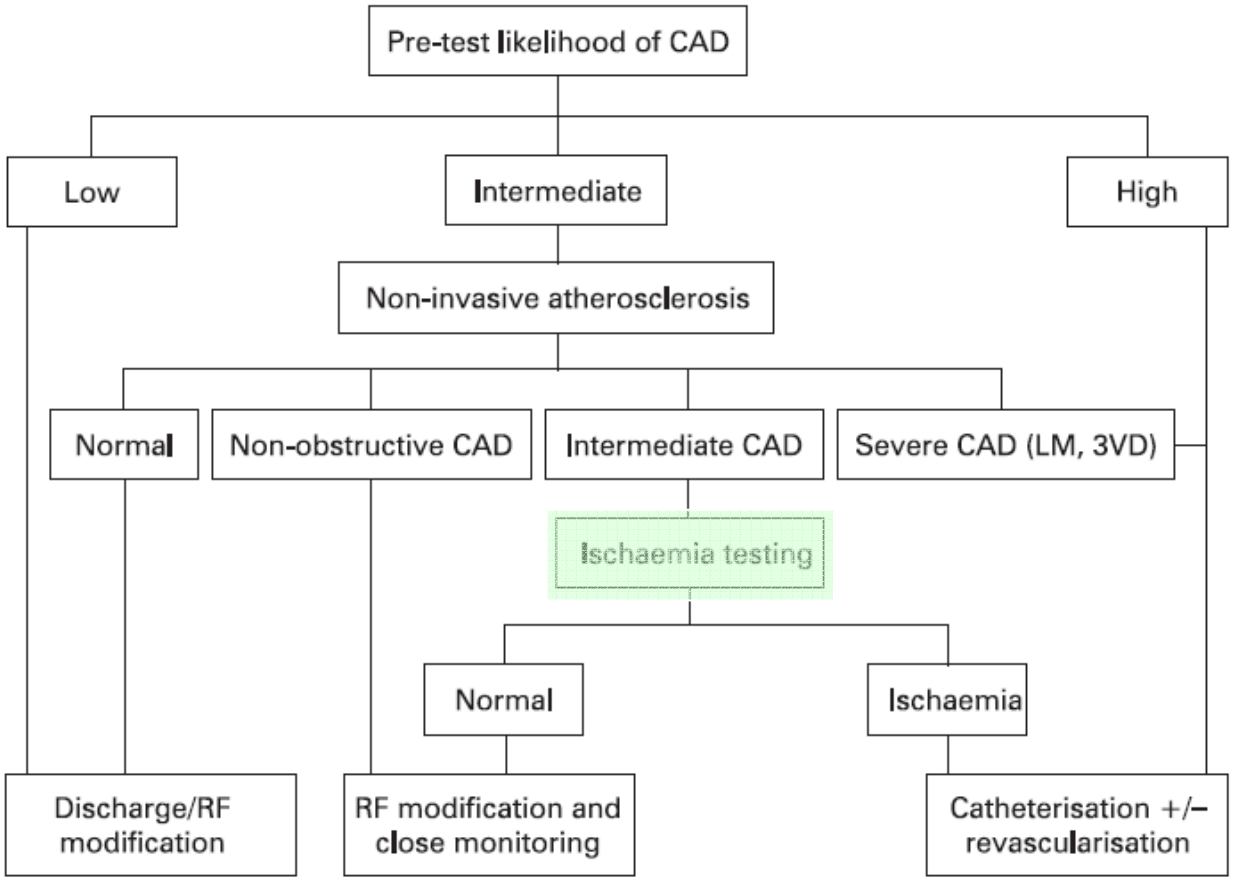


Figure 3 Potential algorithm incorporating non-invasive anatomical and functional testing depending on pretest likelihood of CAD. In patients with low pretest likelihood, no imaging is performed. In patients with high pretest likelihood, referral for invasive coronary angiography is usually performed. In patients with an intermediate pretest likelihood, anatomy may be evaluated first, followed by functional testing or invasive coronary angiography based on the findings. CAD, coronary artery disease, LM, left main disease, 3VD, 3-vessel disease.

Schuijf JD, Bax JJ, Heart 2008