

# Metabolic imaging in viability study

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강원준

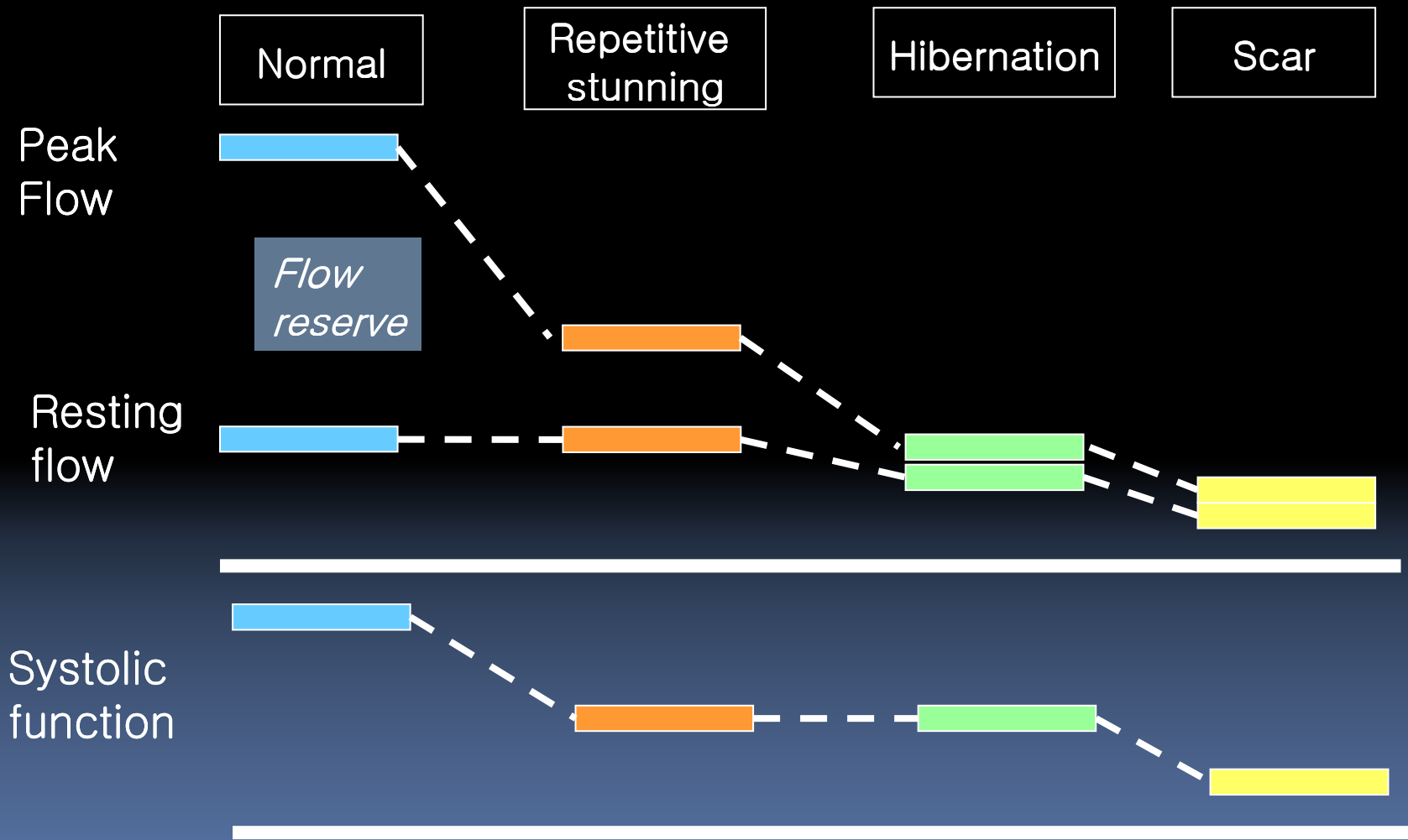
# Definition of myocardial viability

- Viable myocardium
  - Dysfunctional but viable myocardium
  - Potential to recover after revascularization
  - Viable myocytes
- Scar tissue
  - No improvement after revascularization
  - Large extent of fibrosis

# Myocardial viability

- Myocardial Hibernation
  - Perfusion declines
  - Contractile function decreases
- Myocardial Stunning (Repetitive)
  - Transient ischemic episode, prompt normalization of perfusion but delayed recovery of contractile function

# Pathophysiology



# 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 <sup>77</sup>	283	26 (8%)	FDG/N13 ammonia PET	55%
Al-Mohammed <sup>78</sup>	27	19 (6%)	FDG/N13 ammonia PET	52%
Schinkel <sup>79</sup>	104	25 (7%)	FDG/Tc-99m TF SPECT	61%
Fox <sup>80</sup>	27	NA	Tc-99m MIBI/TF SPECT	37%

53% improved in 105 studies

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

# Gold standard for viability

- Improvement of function after revascularization
- LVEF rather than regional function
  - Substantial amount of viable myocardium
- Survival
- Prevention of remodeling, arrhythmia, sudden cardiac death

# Characteristics of viable myocardium

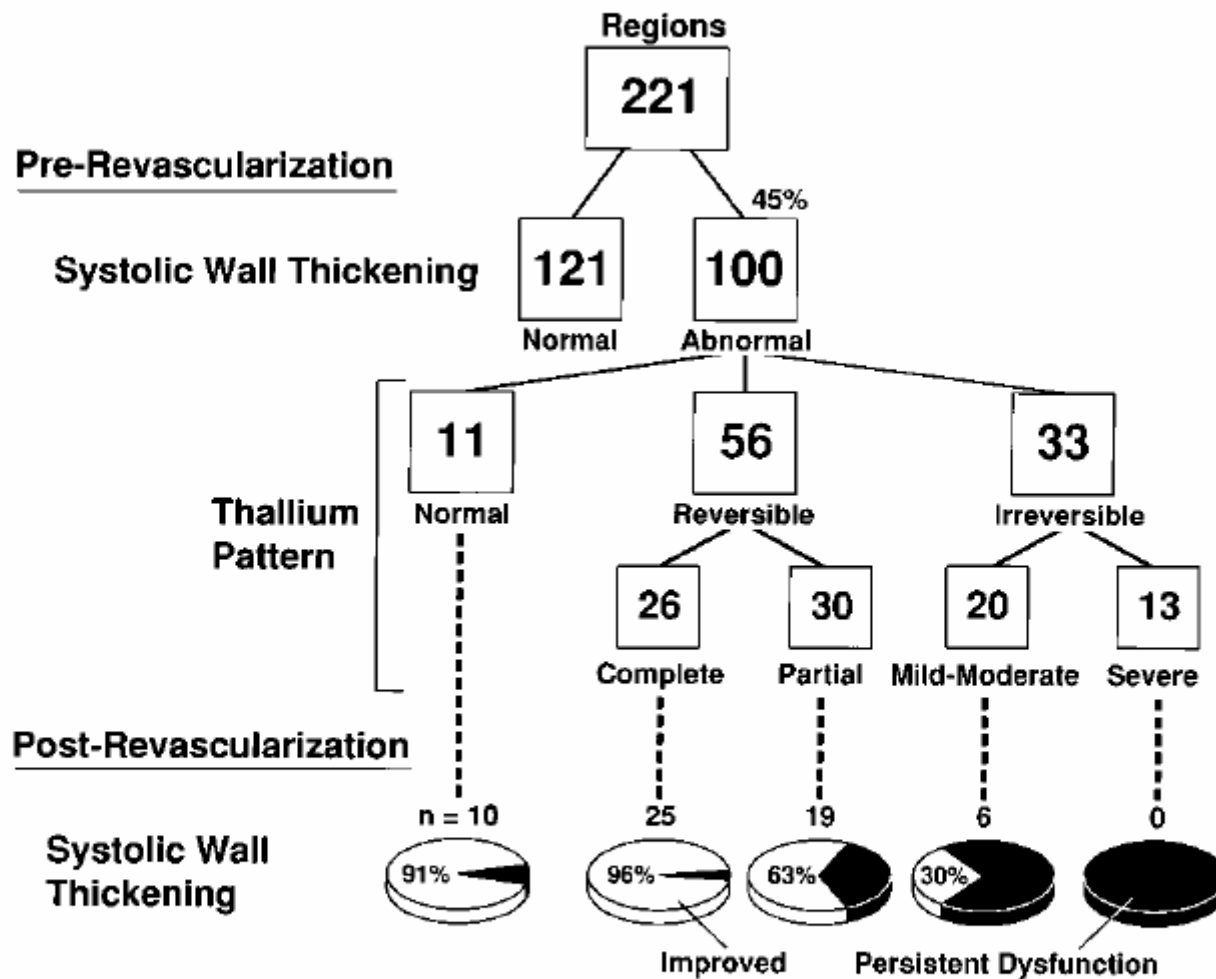
**Table 2** Characteristics of dysfunctional but viable myocardium

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



# Myocardial SPECT





**Figure 4.** Flow diagram of prerevascularization systolic wall thickening and thallium pattern and postrevascularization functional outcome of the 221 revascularized regions.

# M/61, unstable angina

**Stress**

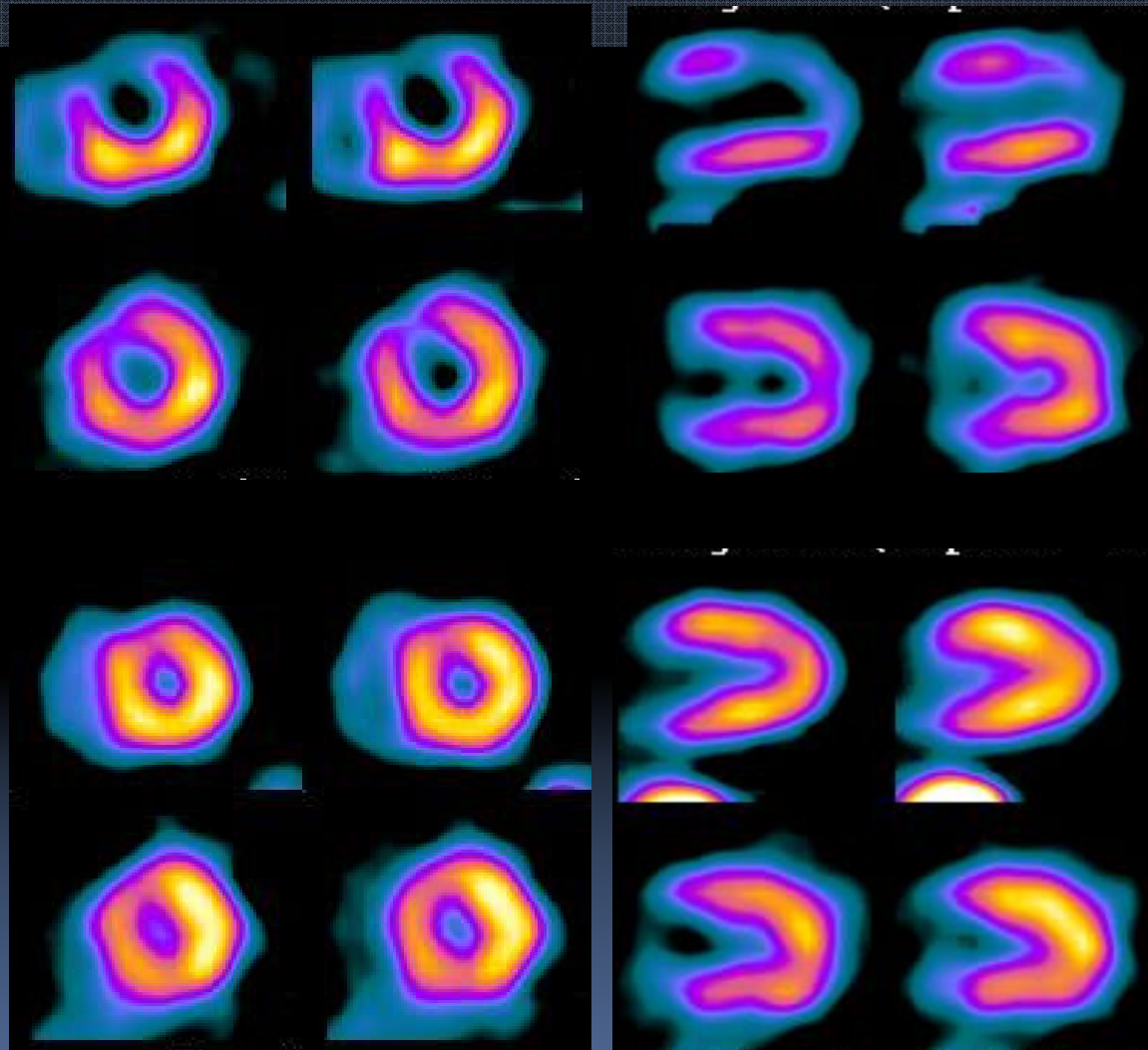
**Pre CABG**

**Rest**

**Stress**

**Post CABG**

**Rest**

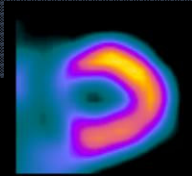


Pre-PCI

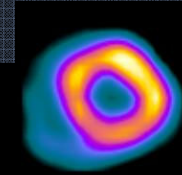
Post-PCI

**Viabile**

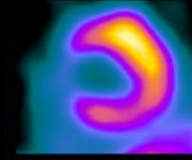
Stress



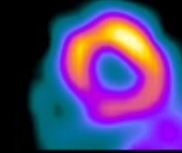
Stress



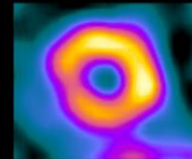
Rest



Rest



Delay

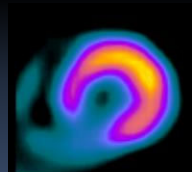


Pre-PCI

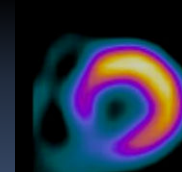
Post-PCI

**Non-viable**

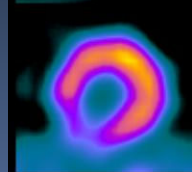
Stress



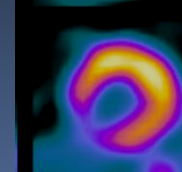
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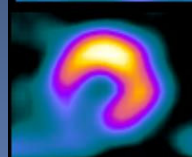
Rest



Rest

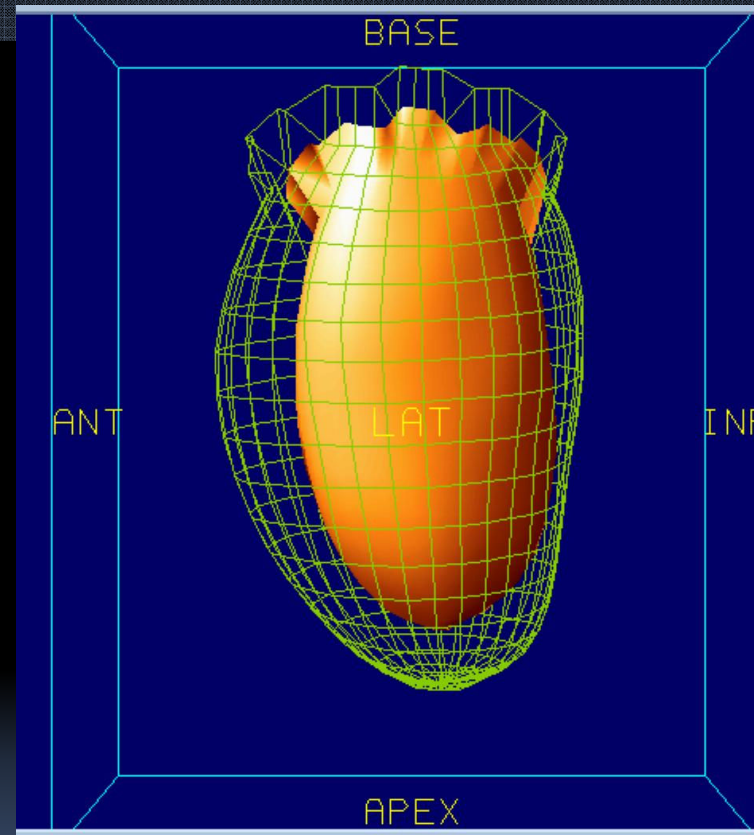
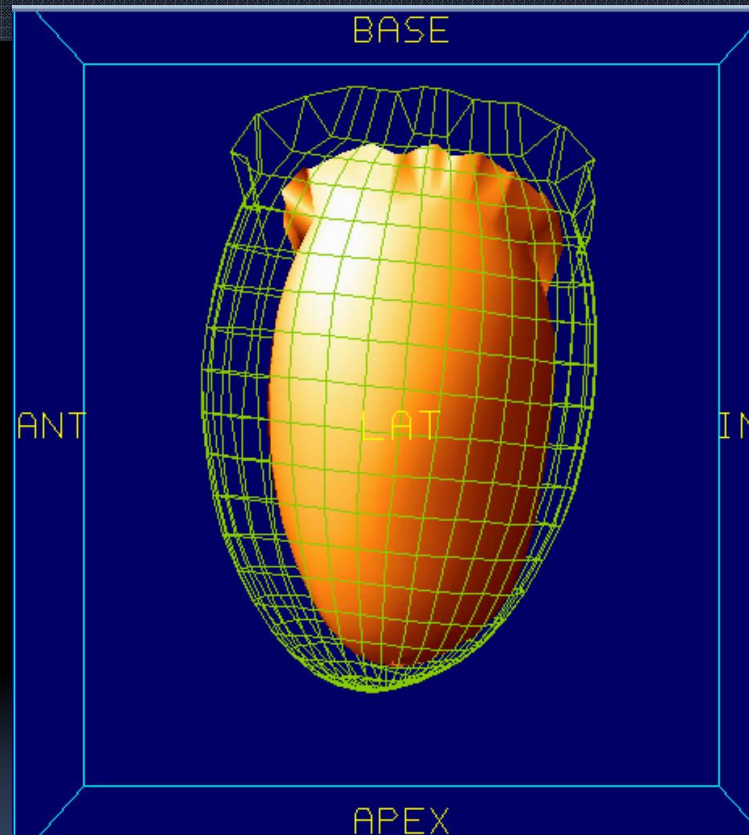


Delay



# RCA, Pre-PCI

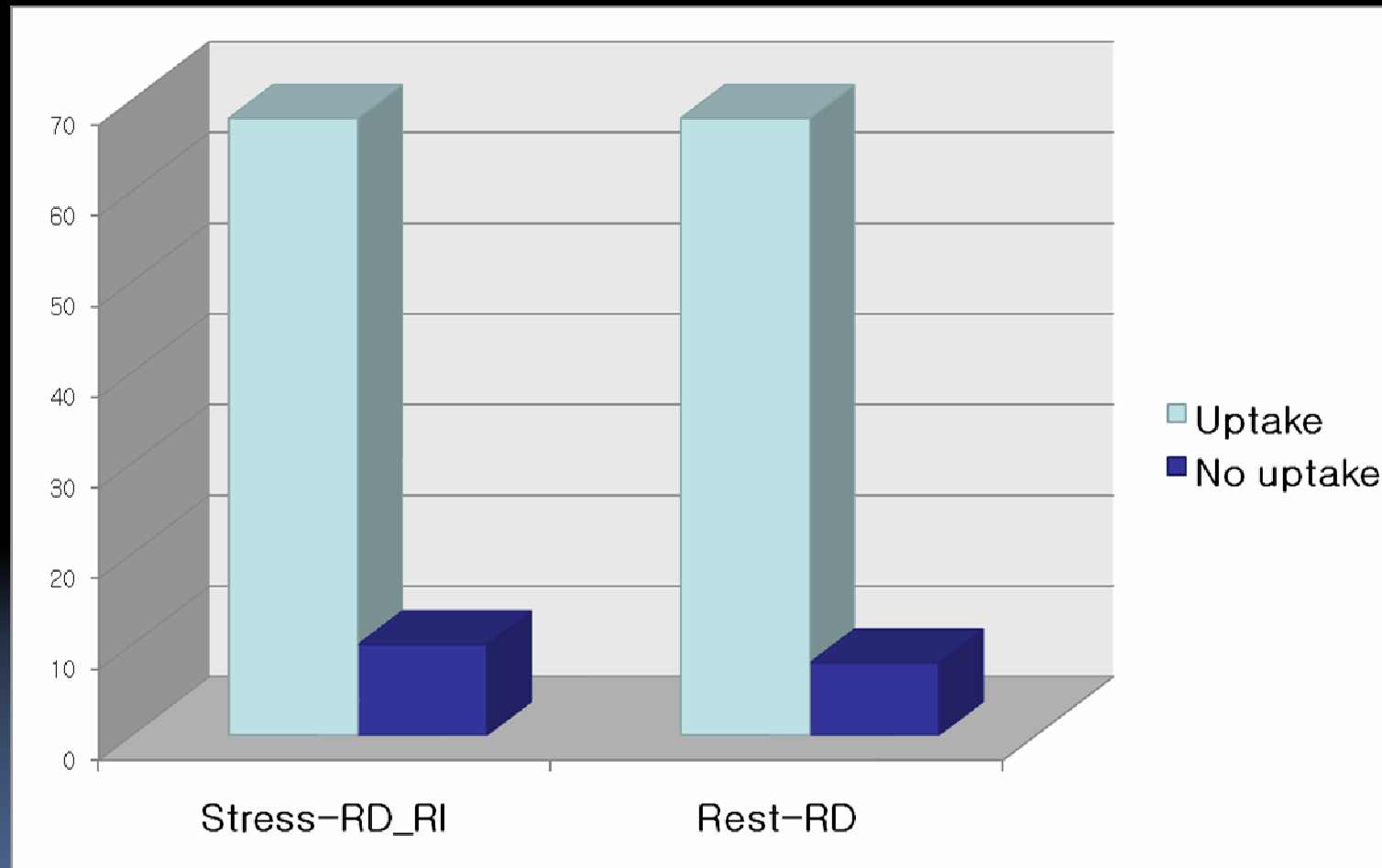
# Post-PCI



ANT	LAT	INF	SEPT	APEX	BASE	LAO	RAO	ECG
<b>Proc ID</b>	C1 CARDIAC TL-MIBI							
<b>View ID</b>	PROC GS							
<b>Date</b>	09/29/2006 12:32:55							
<b>Volume</b>	49ml [5]							
<b>EDV</b>	94ml [16]							
<b>ESV</b>	45ml [6]							
<b>EF</b>	52%							

ANT	LAT	INF	SEPT	APEX	BASE	LAO	RAO	ECG
<b>Proc ID</b>	C1 CARDIAC TL-MIBI							
<b>View ID</b>	PROC GS							
<b>Date</b>	04/11/2006 21:29:53							
<b>Volume</b>	41ml [7]							
<b>EDV</b>	87ml [16]							
<b>ESV</b>	40ml [6]							
<b>EF</b>	54%							

# Prediction of functional recovery with Tl-201



9 studies  
N=295

4 studies  
N=83

Bonow, 1999



PET

# Positron Emission Tomography

- 방사성 핵종
  - $^{18}\text{F}$ -fluorodeoxyglucose(**FDG**) : 포도당 대사
  - $^{11}\text{C}$ -palmitic acid : 지방산 대사
  - $^{13}\text{N}$ -ammonia : 혈류량 측정
  - $^{82}\text{Rb}$ (rubidium) : 혈류량 측정

## ■ 임상 응용

### □ 정상 심근

공복시 : 지방산 대사가 주로 일어남.

$^{11}\text{C}$ -palmitic acid의 균등한 섭취

식사 후 : 일시적으로 포도당 대사가 항진

$^{18}\text{F}$ -FDG 섭취

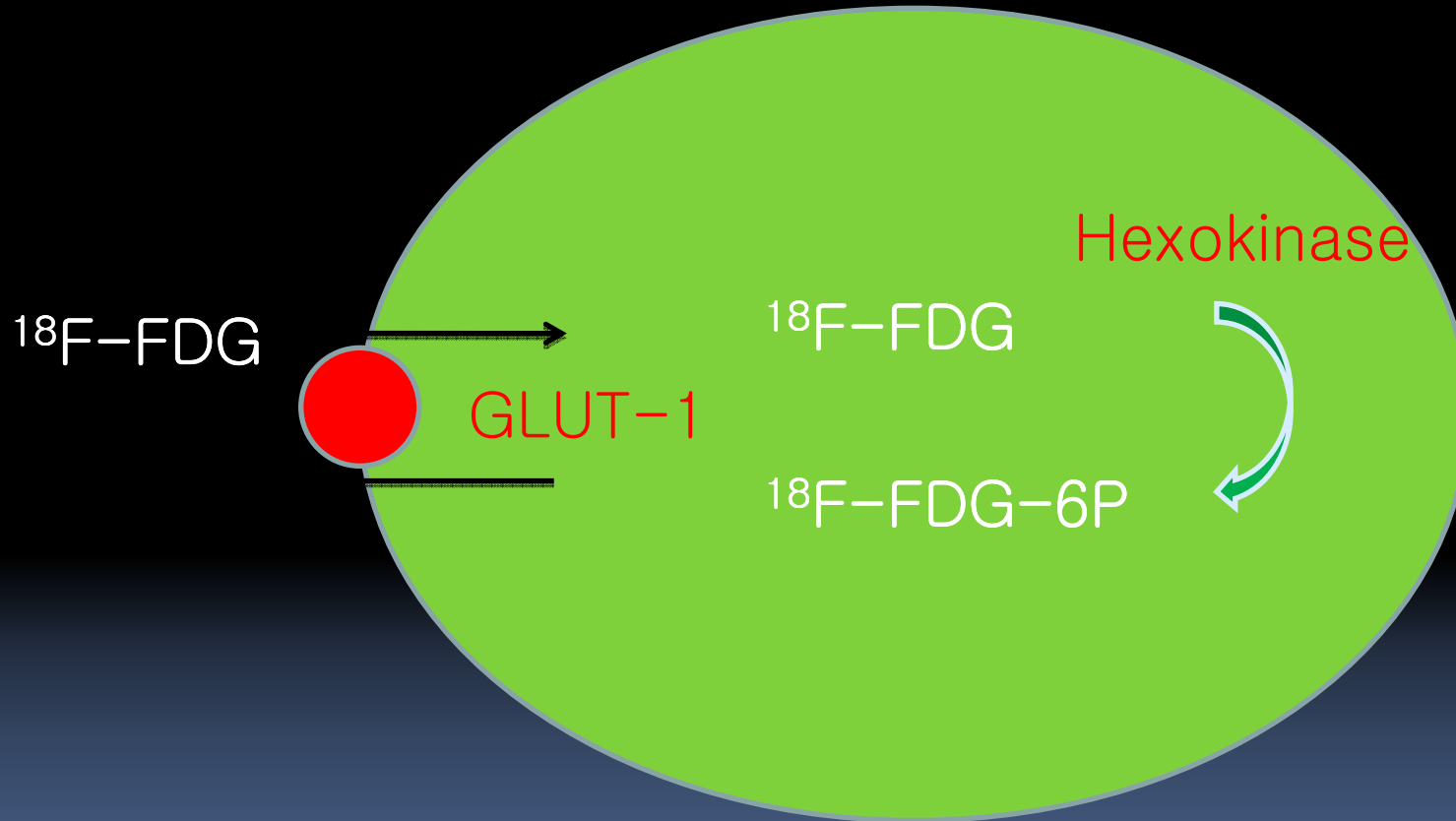
### □ 심질환

$^{13}\text{N}$ -ammonia: 혈류 검사

$^{18}\text{F}$ -FDG: viability study



# FDG

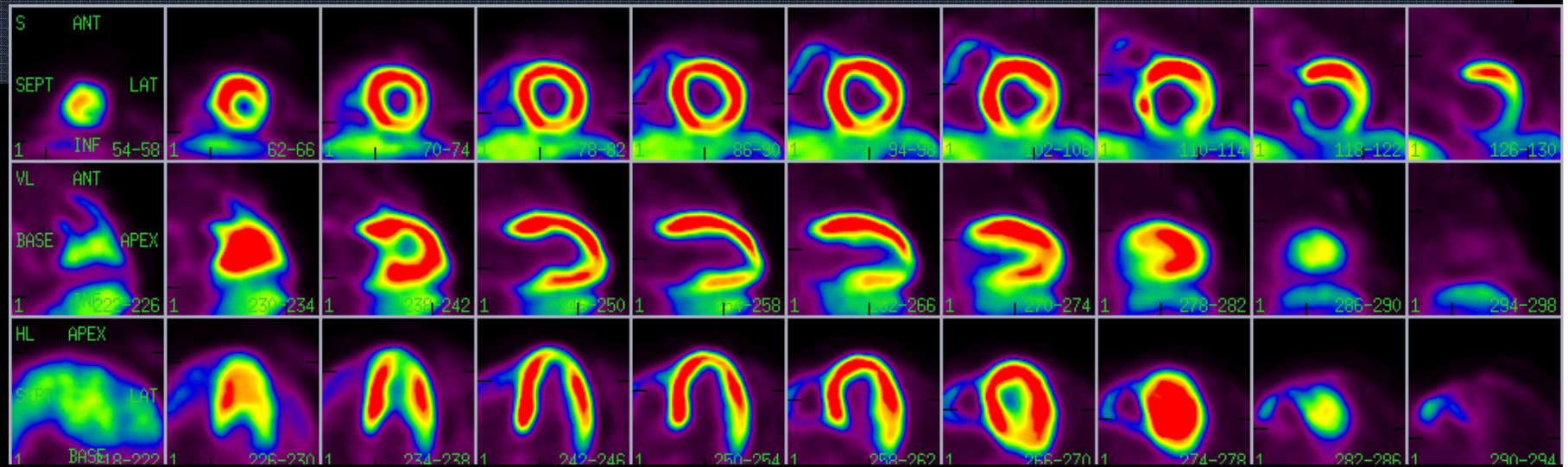


More basal characteristics than contractile reserve

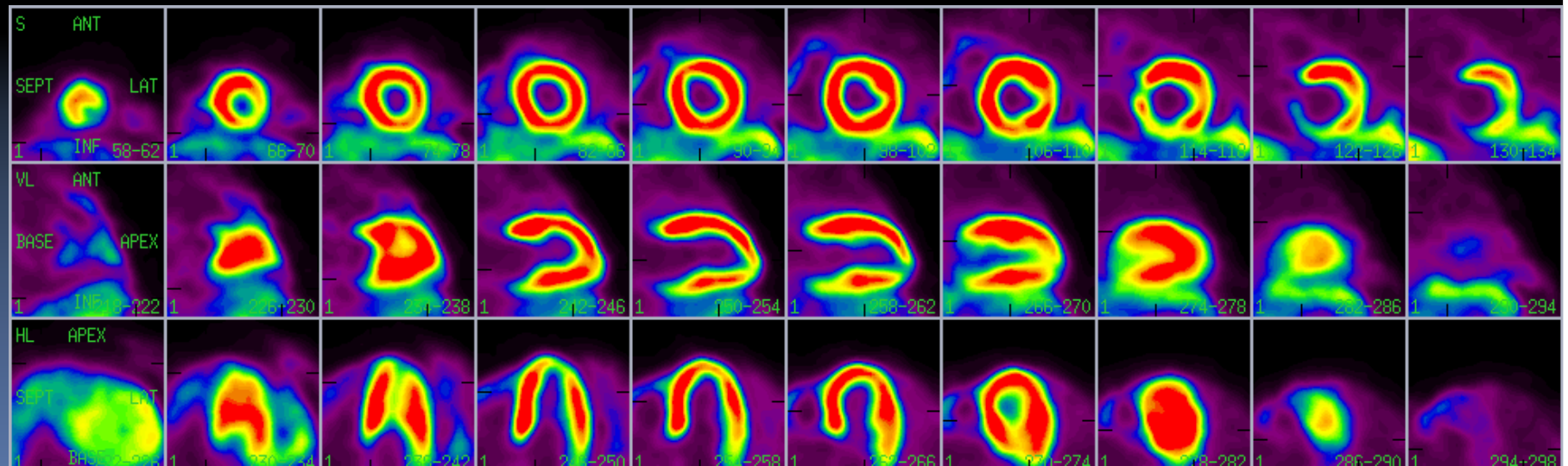
# Comparison of Perfusion and metabolism

	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<sub>3</sub> Stress



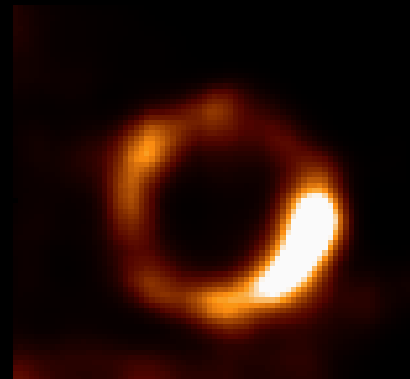
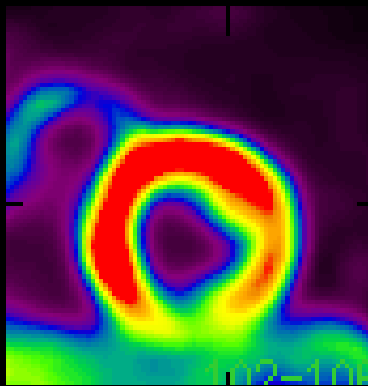
# NH<sub>3</sub> Rest



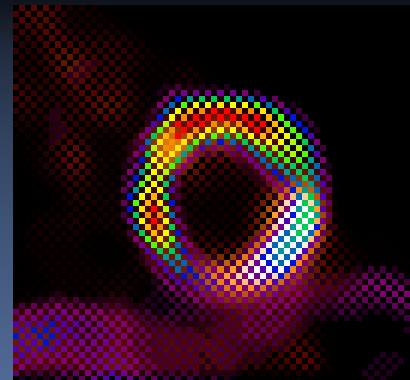
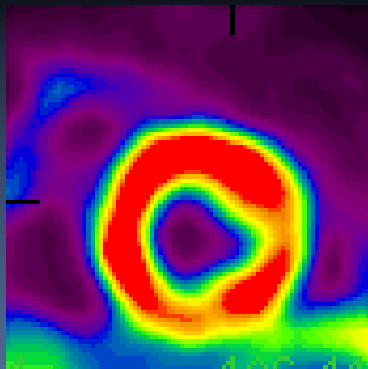
NH<sub>3</sub> PET

FDG PET

Stress



Rest





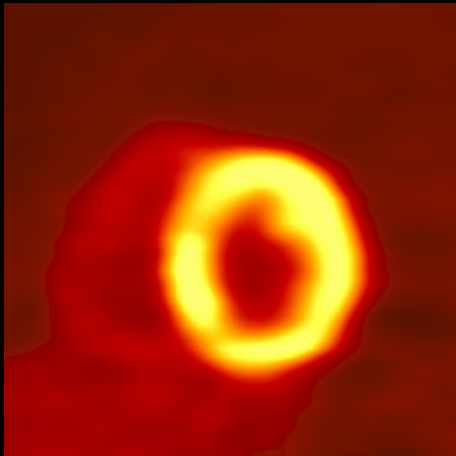
STRESS 03Nov2003

REST

STRESS

REST

Short axis (Apex-->Base)



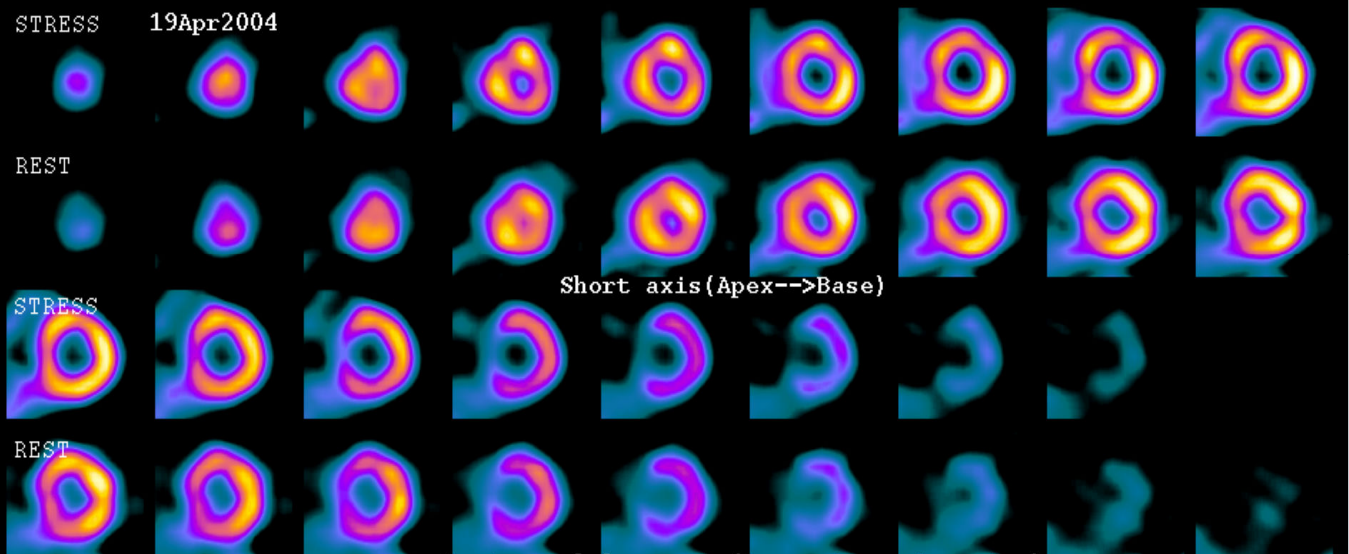
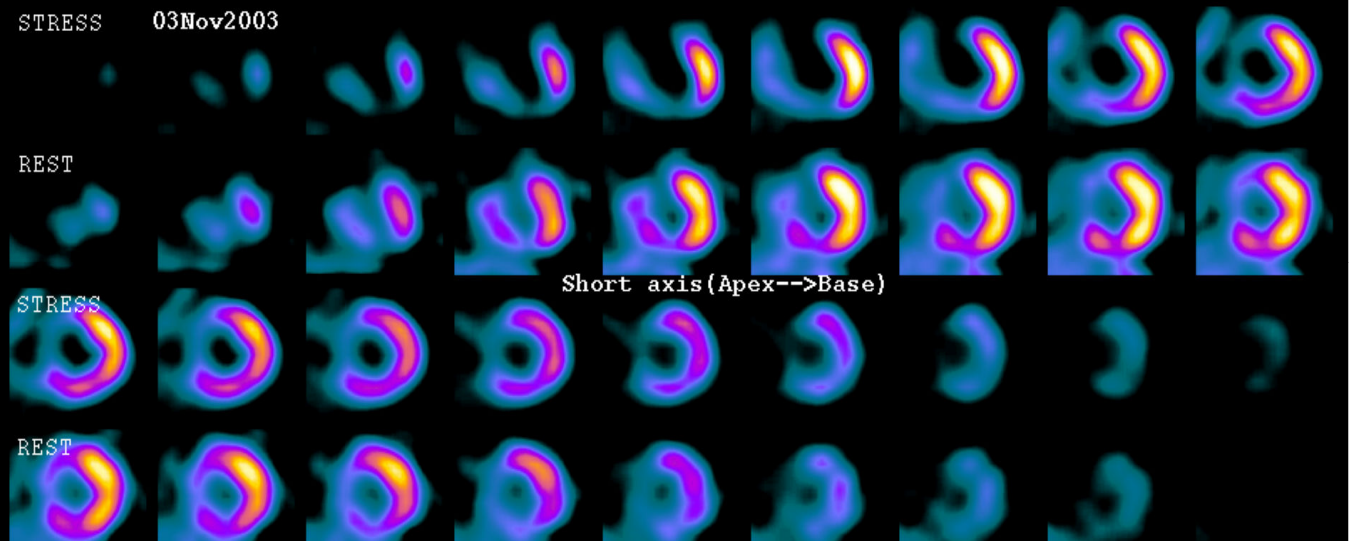
STRESS 19Apr2004

REST

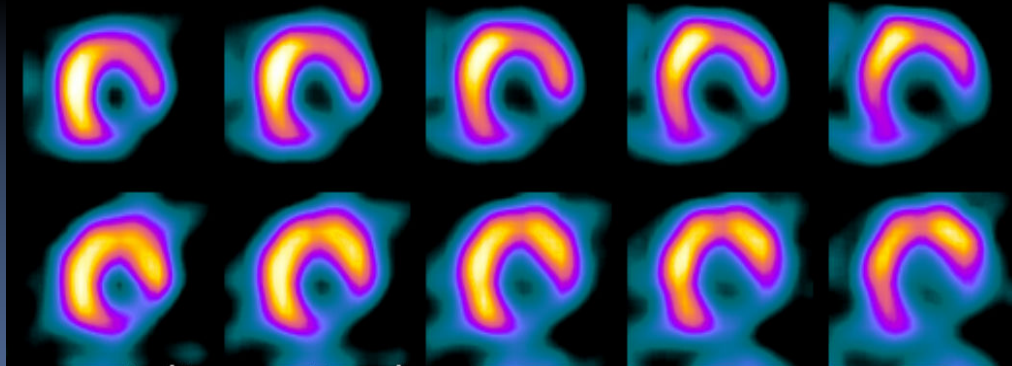
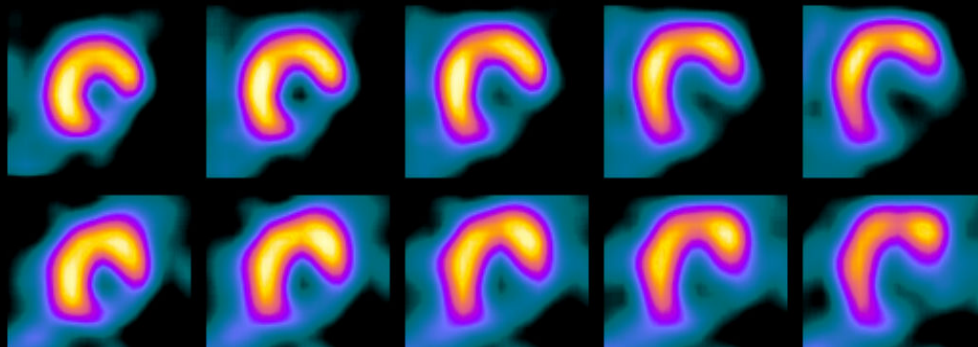
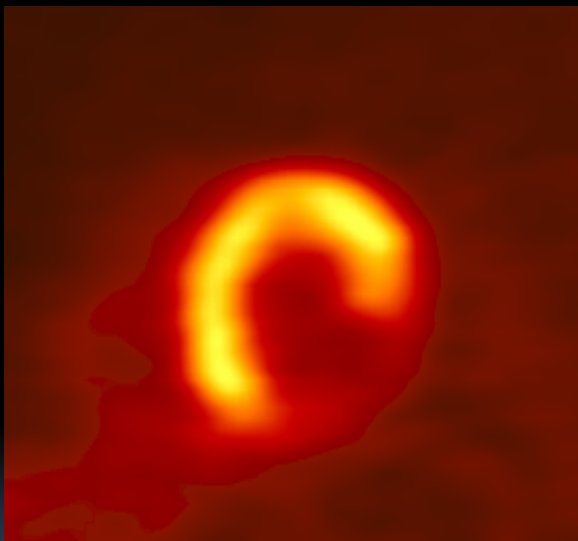
STRESS

REST

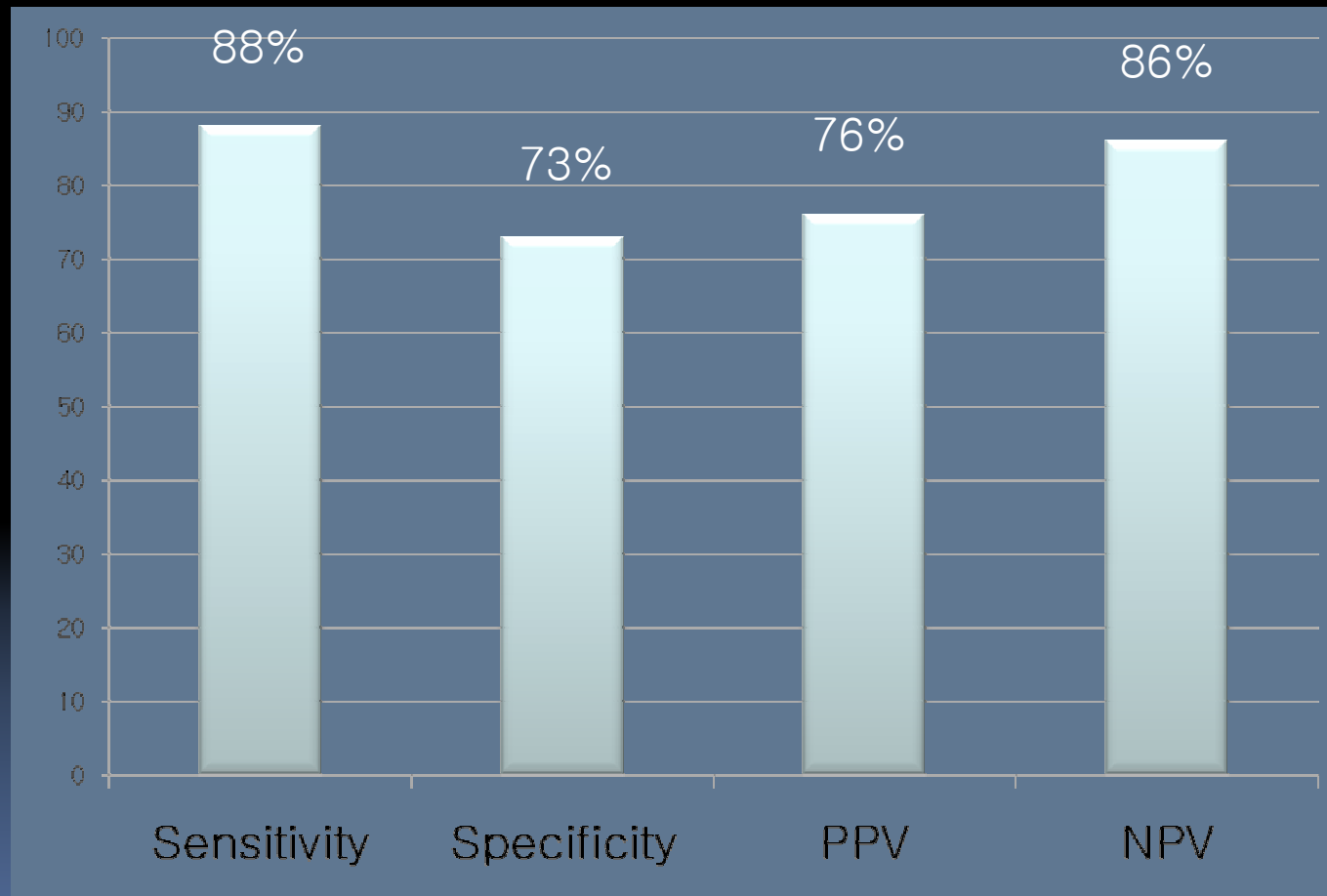
Short axis (Apex-->Base)







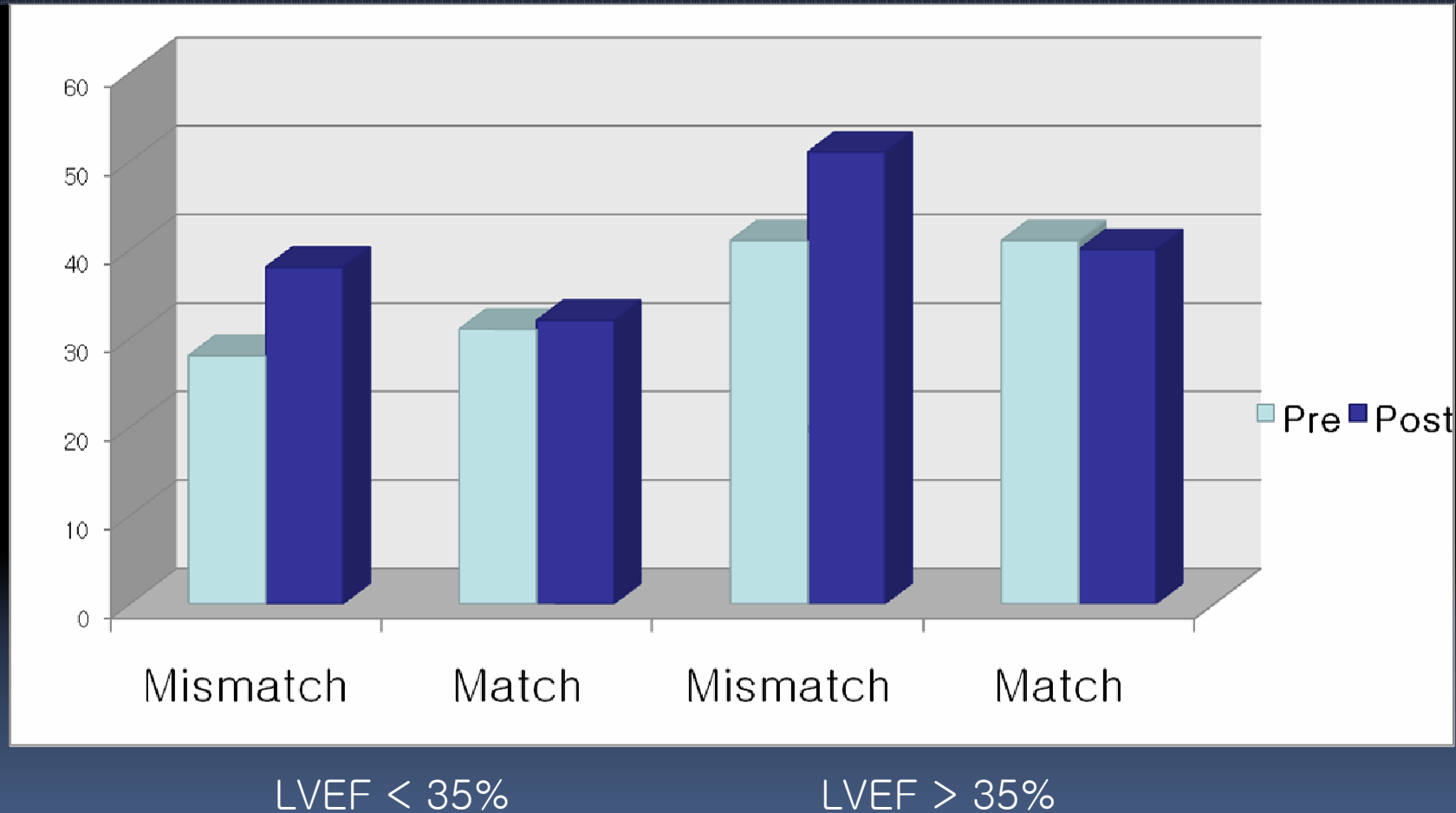
# Accuracy of FDG PET in regional function improvement



Bax et al, JACC 1997  
12 studies, N=332

# Prediction of LVEF Improvement

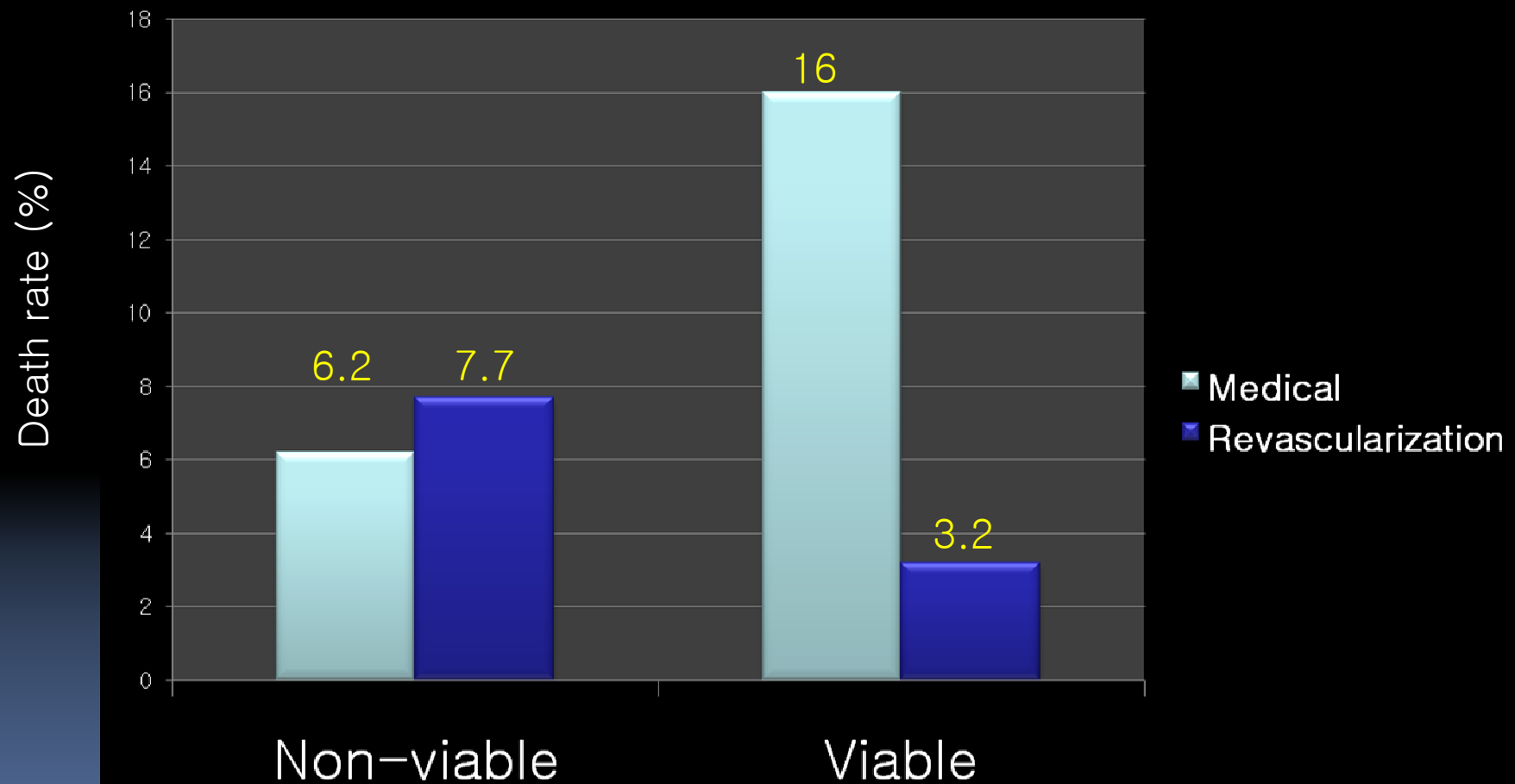
25 studies, 772 patients





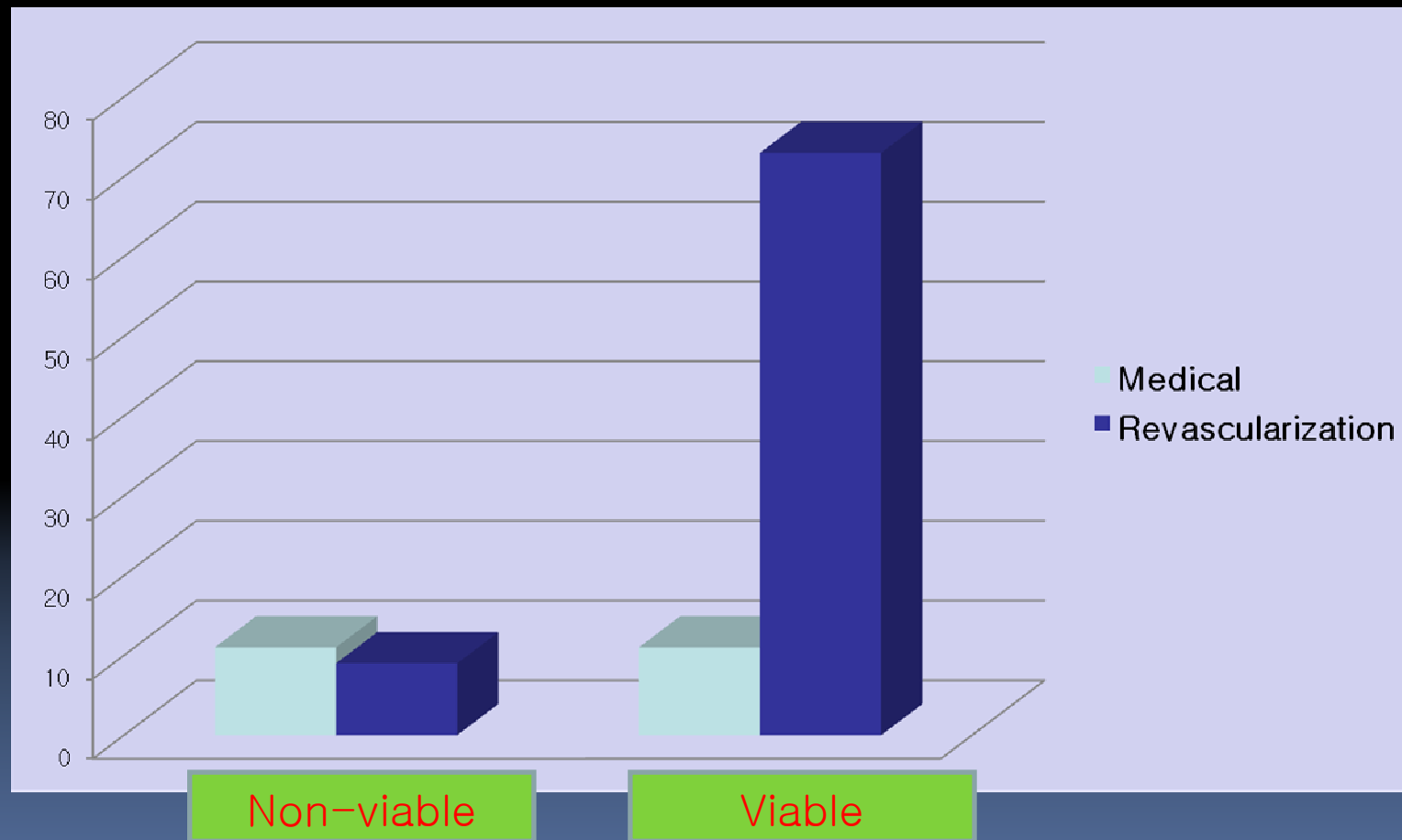
# Prognosis

Meta-analysis of 24 studies (3088 patients)



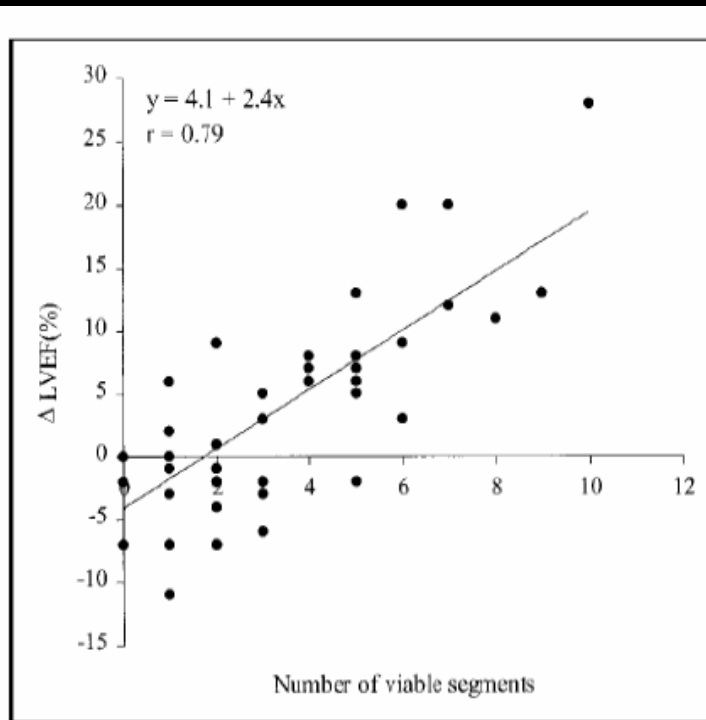
Allman KC, JACC 2002

# Prediction of Heart Failure Symptoms Improvement

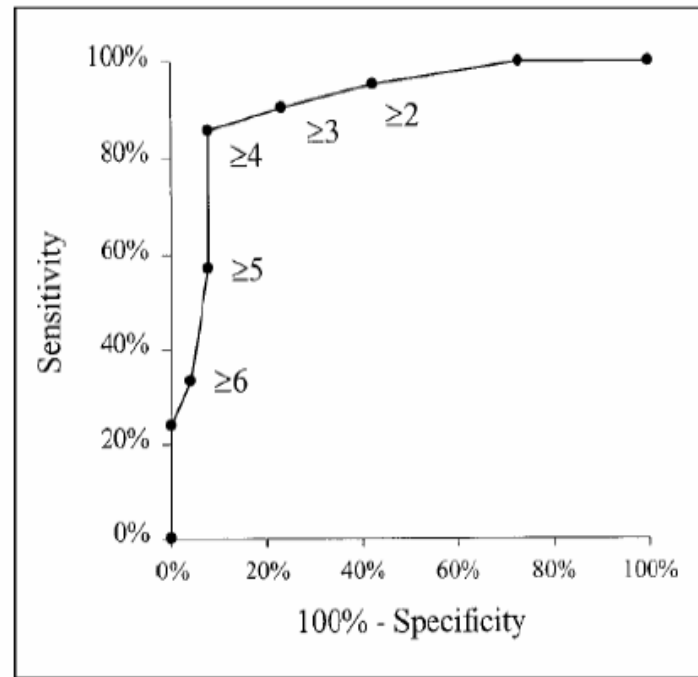


Di Carli, Am J Cardiol 1994

# How much viable myocardium needed for LVEF improvement?



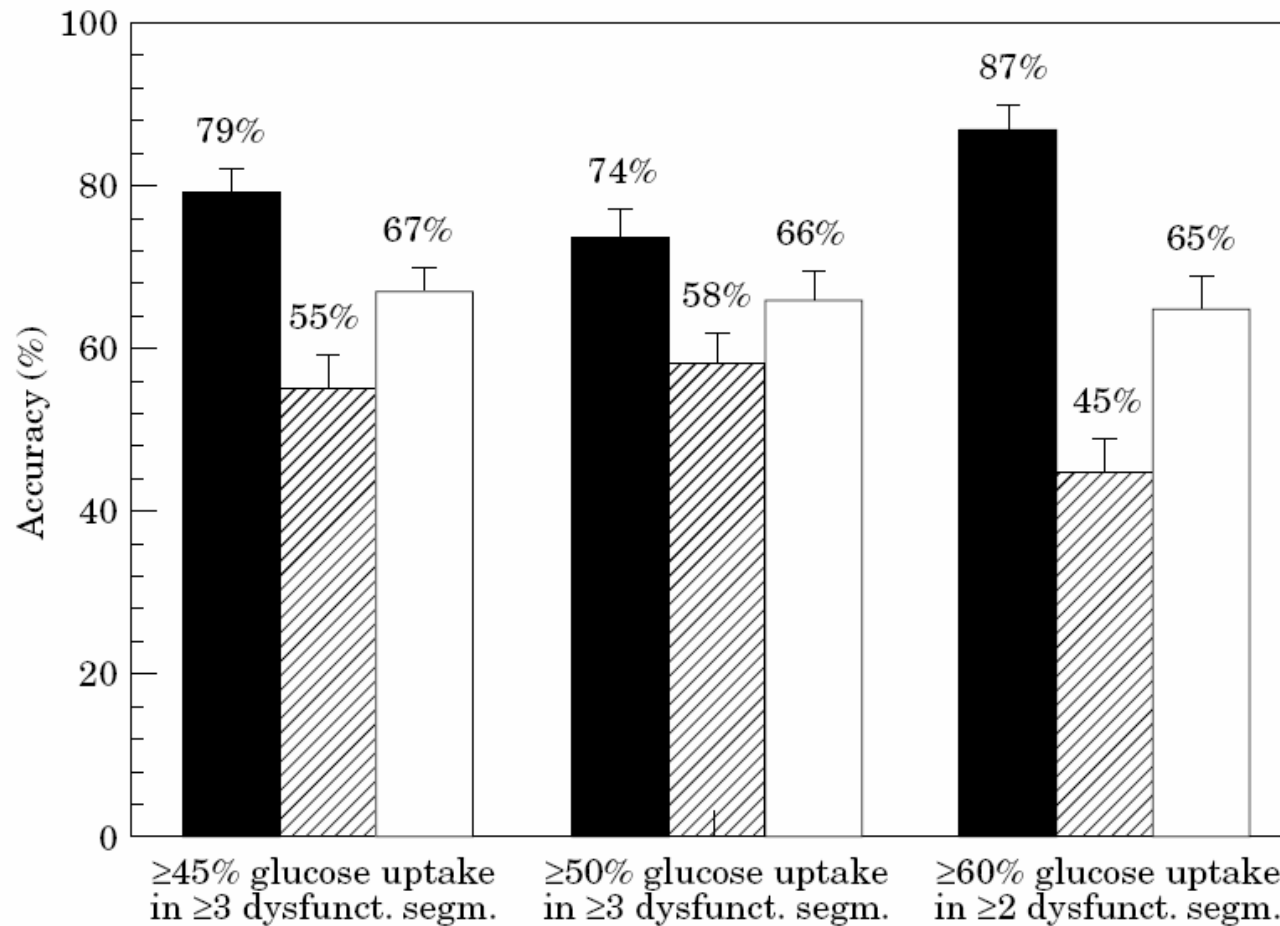
**FIGURE 2.** Scatterplot showing significant relationship between number of viable segments on SPECT and improvement in LVEF after revascularization ( $y = 4.1 + 2.4x$ ,  $r = 0.79$ ,  $P < 0.001$ ).



**FIGURE 3.** ROC curve analysis showing that cutoff level of four dysfunctional but viable segments yielded highest sensitivity and specificity to predict functional outcome on patient basis.

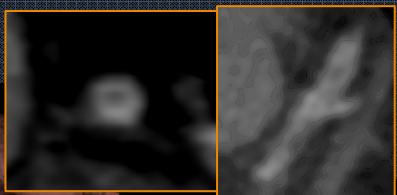
20–30% of LV

Bax JJ, J Nucl Med 2001



**Figure 5** Sensitivity ■, specificity ▨, and accuracy □ for the prediction of postoperative improvement of ejection fraction by more than 5% using different cut-off points, as determined by receiver operating curve analysis. Error bars indicate standard deviation of mean.

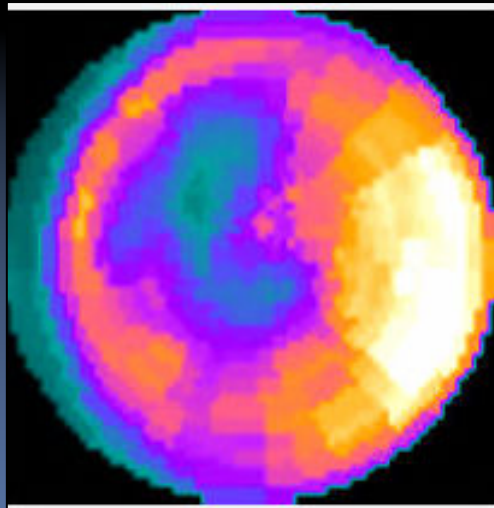
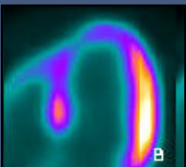
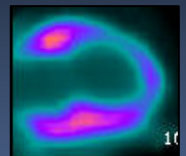
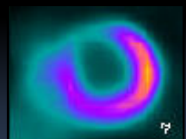
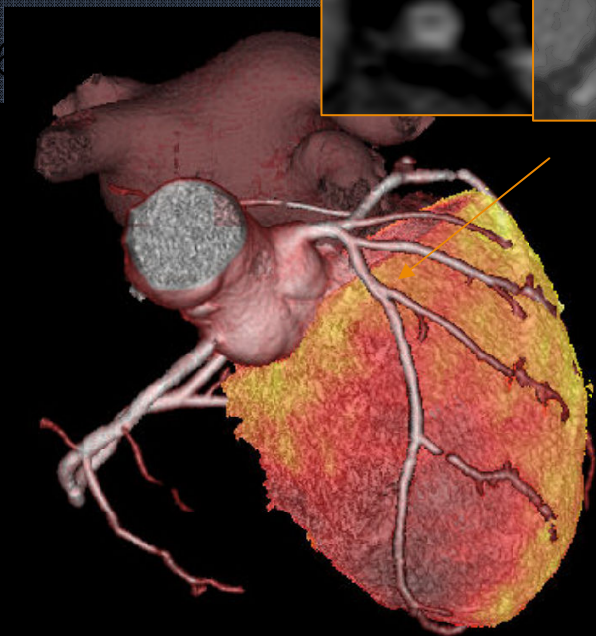
FDG PET/CT



376  
508

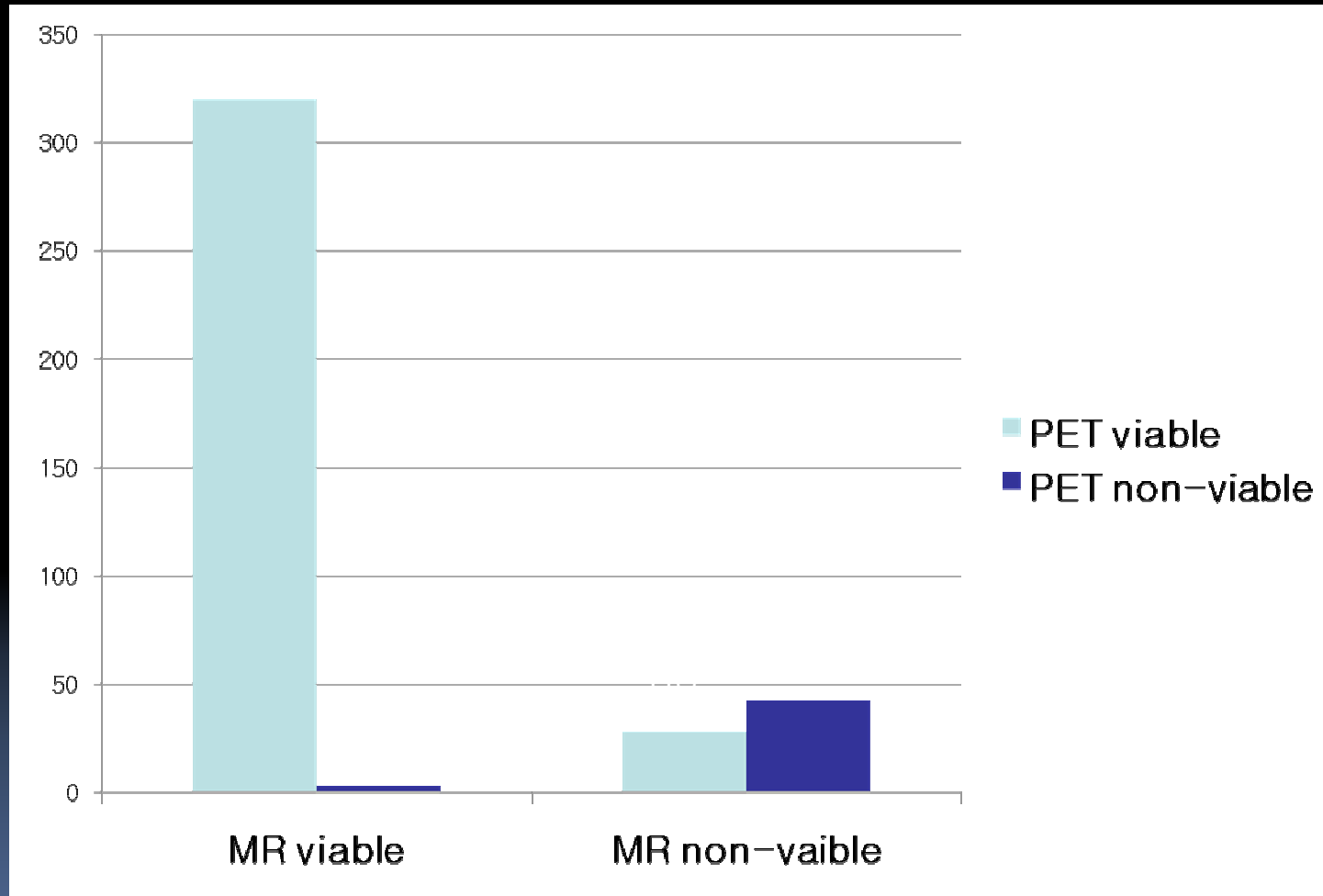
GO JONG-CHOL

May 16, 2011  
01:50:31



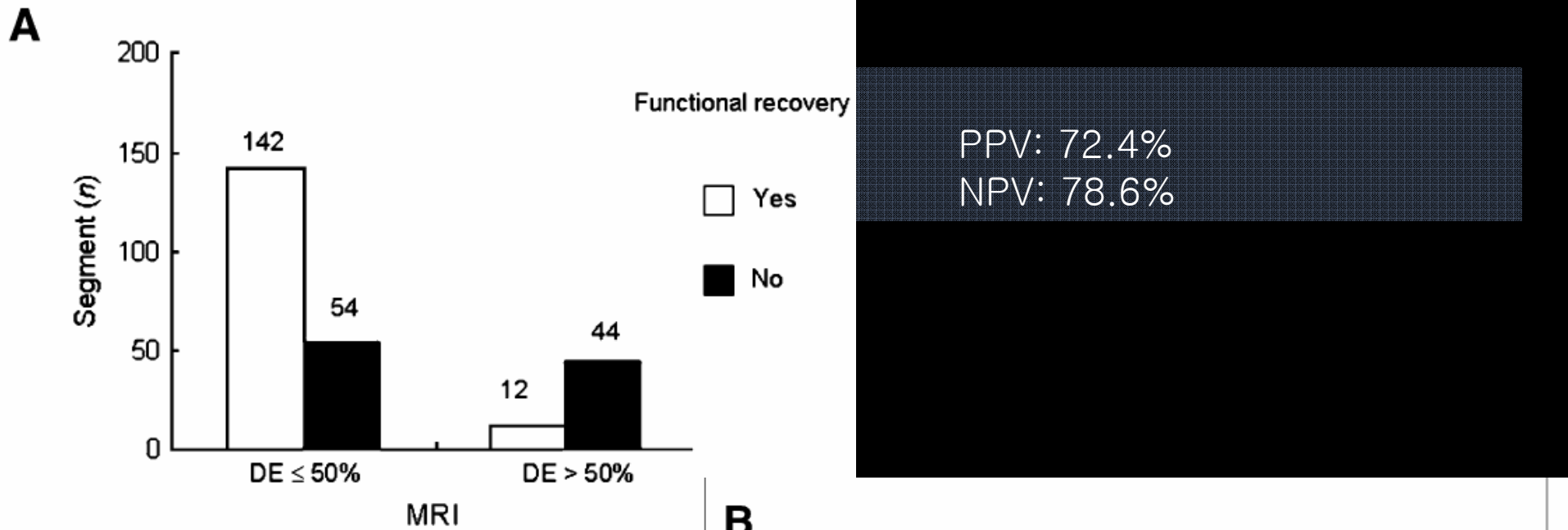
Courtesy of Cho IH  
Yeoungnam University

# Comparison of MRI with FDG PET



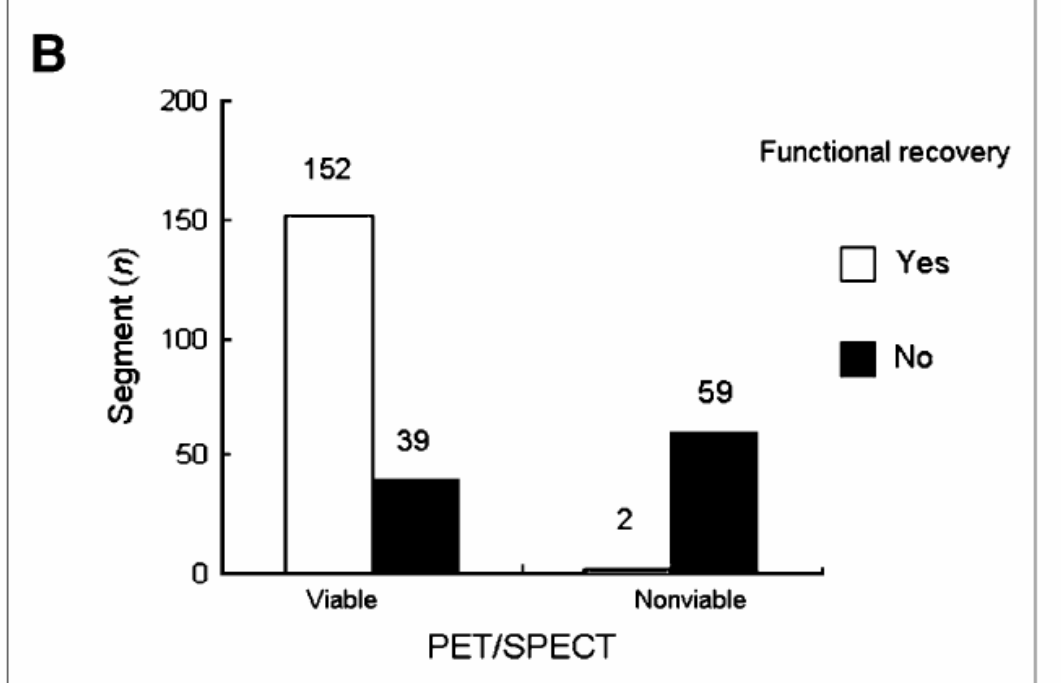
**TABLE 3**Transmurality of DE in Dysfunctional Myocardium ( $n = 394$ )

PET/SPECT	Extent of transmuralty on MRI				
	None	1%–25%	26%–50%	51%–75%	76%–100%
Viable	258	24	38	18	10
Nonviable	0	0	3	22	21



PPV: 76.6%  
NPV: 96.7%

Wu Y-W et al. JNM 2007



**FIGURE 2.** Relation between segmental viability status by MRI categorization (A) and <sup>18</sup>F-FDG PET/<sup>201</sup>Tl SPECT (B) and early functional outcome after surgical revascularization (n = 252).

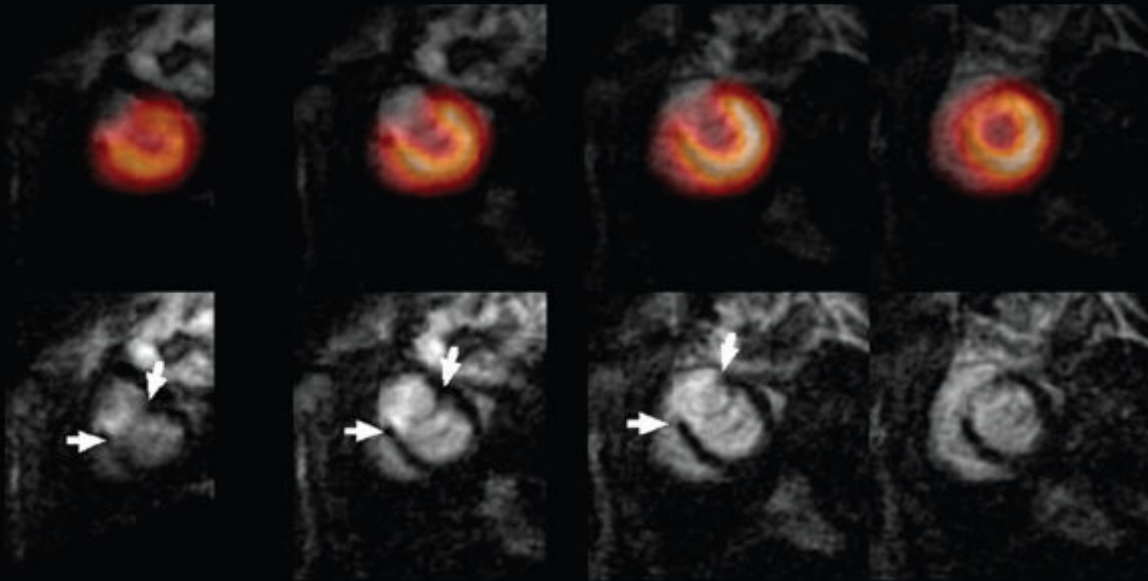


**A**

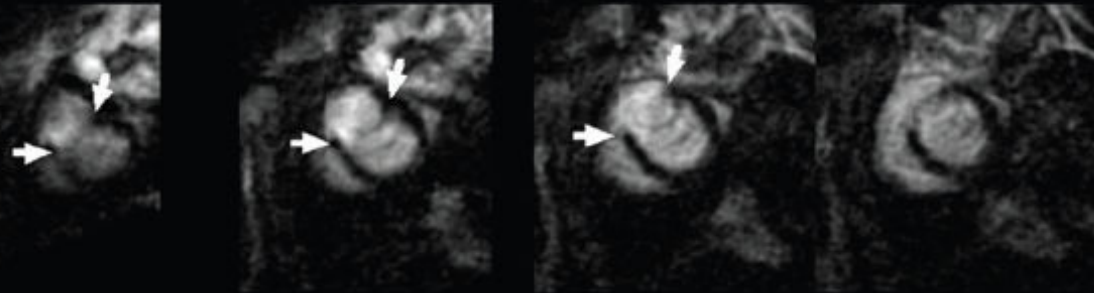
$^{18}\text{F}$ -FDG



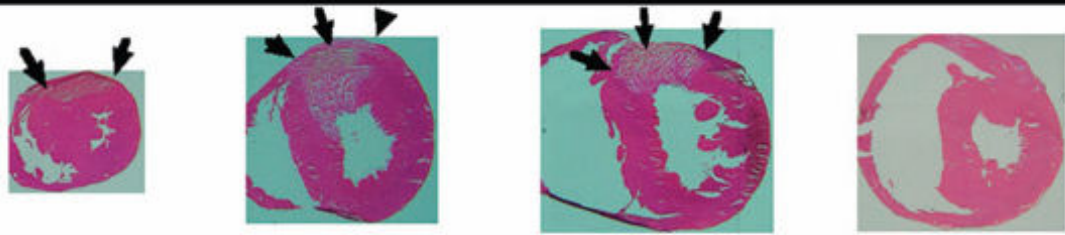
Fusion



ceMRI



Histology  
(HE)

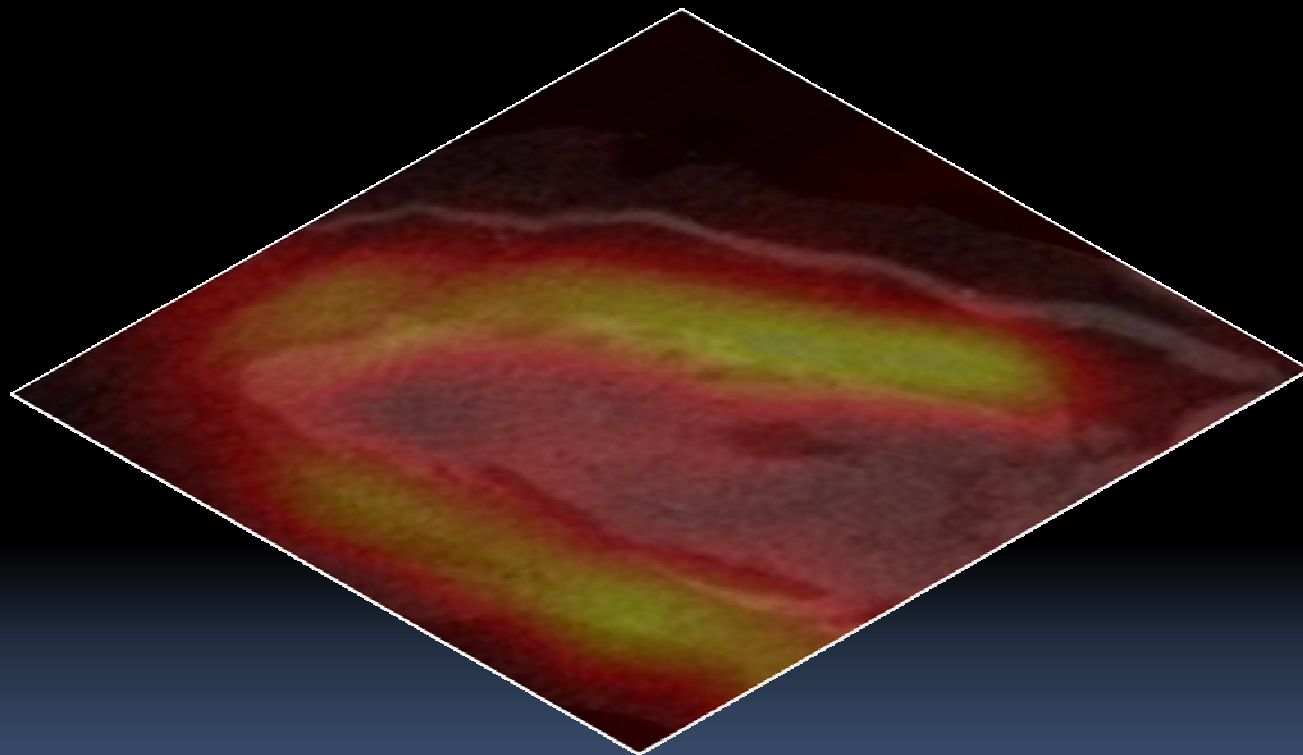


Apex



Base

# PET/CT



# Conclusion

- Viability study: function, symptoms, remodeling, prognosis
- FDG PET
  - Respiratory gating, EKG gating
  - Fusion software: with CT, MRI, SPECT
  - 64 slices CT: vascular information
  - 보형

