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# FFR and Acute Coronary Syndromes

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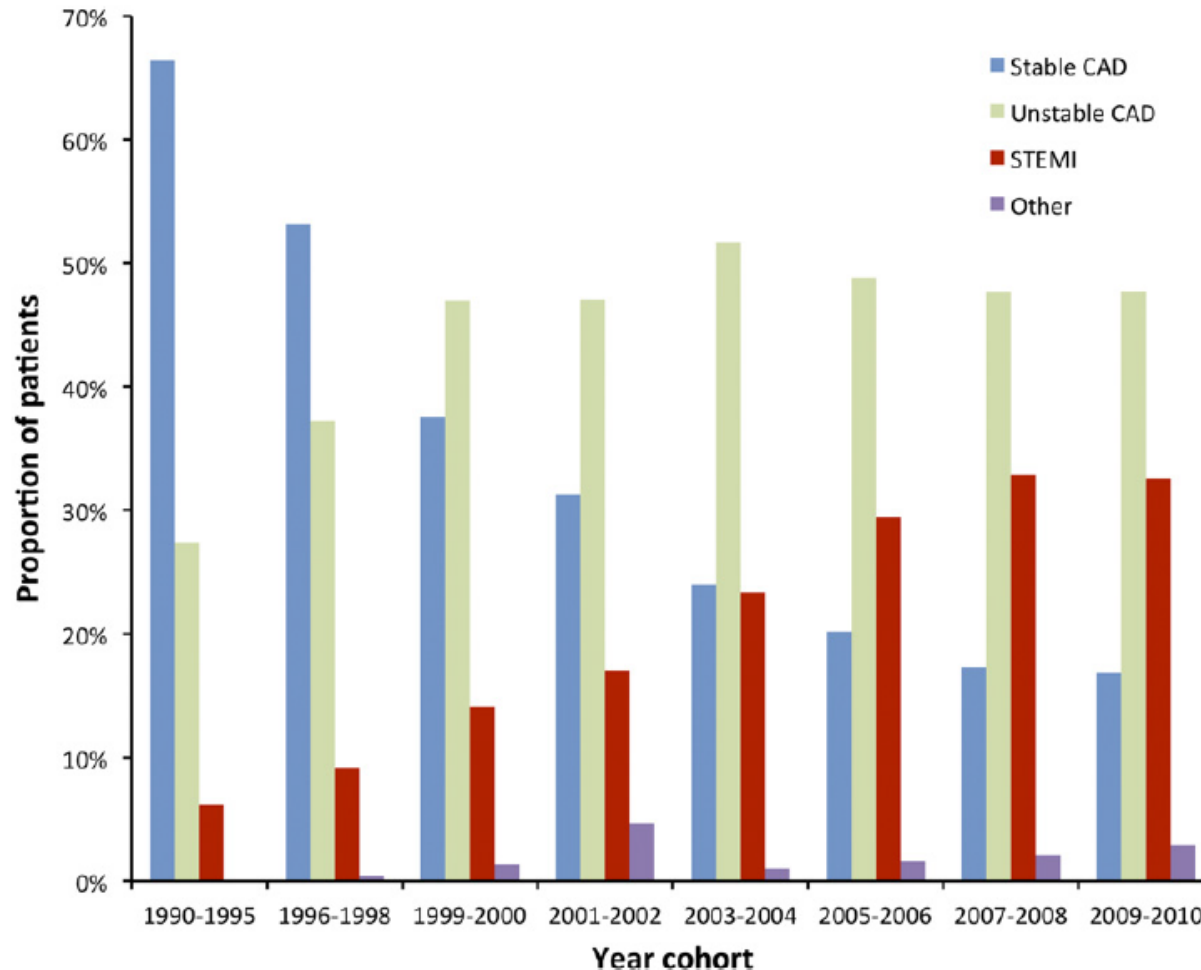
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# Increasing Prevalence of ACS

*144,039 Swedish patients (SCAAR Registry) undergoing PCI between 1990-2010*



# Increasing Prevalence of ACS

- 500,154 PCI's performed in the US between 2009-2010 were included in the NCDR
- 71% of these procedures were in patients presenting with an acute coronary syndrome



# Overview of FFR in ACS:

- STEMI
  - Acute
  - Chronic
- Non-STEMI
  - Acute
- Culprit vessel
- Non-Culprit vessel

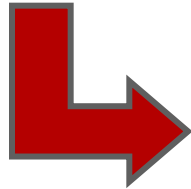


# Acute Microvascular Damage and FFR

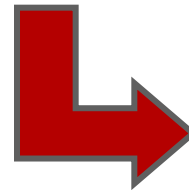
*STEMI*



*Variable Degree of  
Reversible Microvascular  
Stunning*



*Maximum Achievable  
Flow is Less*



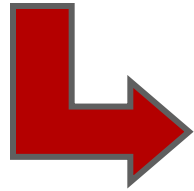
*Smaller Gradient and  
Higher FFR across  
Any Given Stenosis*

*With time, the microvasculature may recover, maximum achievable flow may increase, and a larger gradient with a lower FFR may be measured across a given stenosis*

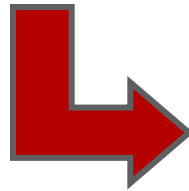


# Chronic Microvascular Damage and FFR

*Old Myocardial  
Infarction*

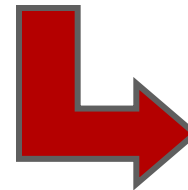


*Irreversible Microvascular  
Damage*



*Maximum Achievable  
Flow is Less*

*In the setting of chronic microvascular dysfunction, the higher FFR is not falsely elevated, but reflects the smaller amount of viable myocardium supplied by the vessel and still provides information about the expected gain in flow after PCI*



*Smaller Gradient and  
Higher FFR across  
Any Given Stenosis*



# FFR in Acute STEMI (Culprit Vessel)

*FFR after stenting in 33 AMI patients  
compared to 15 stable angina patients*

<u>IVUS Parameters</u>	<u>AMI</u>	<u>Angina</u>	<u>P</u>
Ref Lumen Area	7.45 ±2.4	6.49 ±1.6	NS
Min Lumen Area	5.28 ±1.7	5.03 ±1.1	NS
% Area Stenosis	27.3 ±9.3	25.76 ±13.1	NS
<u>Pressure Parameter</u>			
FFR	0.95 ±0.04	0.90 ±0.04	0.003



# FFR in Acute STEMI (Culprit Vessel)

*FFR after stenting in 33 AMI patients comparing those with TIMI 3 flow (n=23) to those with TIMI 2 flow (n=10)*

IVUS Parameters	TIMI 3	TIMI 2	P
Ref Lumen Area	7.69 ±2.6	6.89 ±1.8	NS
Min Lumen Area	5.48 ±1.7	4.86 ±1.7	NS
% Area Stenosis	26.3 ±9.0	30.17 ±9.8	NS
<u>Pressure Parameter</u>			
FFR	0.93 ±0.04	0.98 ±0.02	<0.01





# FFR in Chronic MI (Culprit Vessel)

*Changes in flow with and without microvascular dysfunction*

	MI	No MI	P
Target lesion, n	22	21	
Pre-/postintervention, n	7/15	10/11	0.2
Diameter stenosis, %	43 ± 22	44 ± 16	0.9
MLD, mm	1.7 ± 0.8	1.6 ± 0.6	0.6
Length, mm	9.1 ± 4.0	7.3 ± 3	0.1
Reference diameter, mm	2.9 ± 0.5	2.8 ± 0.6	0.6
Flow velocity measurements			
APV (basal), cm/sec	17 ± 7	17 ± 8	0.8
APV (hyperemic), cm/sec	26 ± 13	36 ± 16	0.03
Coronary flow reserve	1.5 ± 0.3	2.1 ± 0.4	< 0.0001
Flow (hyperemic), ml/min	37 ± 26	48 ± 22	0.03
Pressure measurements			
Gradient (hyperemic), mm Hg	13 ± 11	21 ± 13	0.05
FFR, %	82.6 ± 12.5	79.0 ± 11.7	0.3



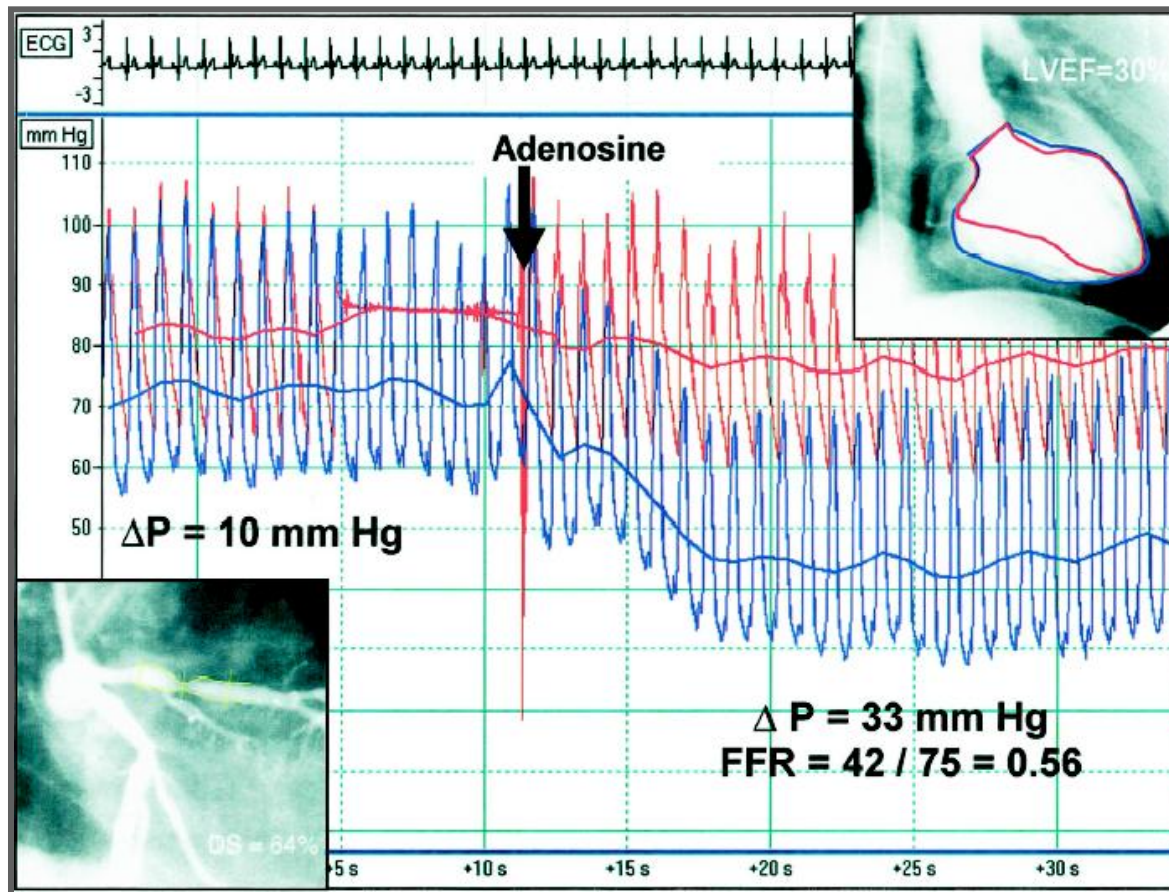
# FFR in ACS

***How long do we have to wait after a STEMI before FFR can be reliably measured in the culprit vessel?***



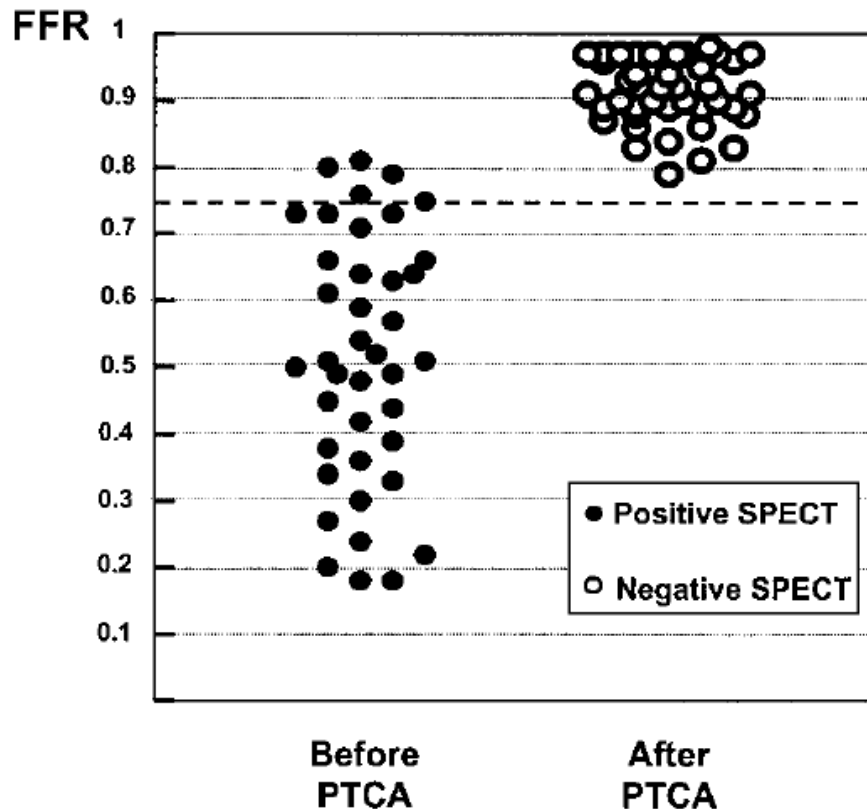
# FFR after Recent MI (Culprit Vessel)

*Comparison of FFR in 57 patients with an MI  $\geq 6$  days old to SPECT imaging before and after PCI*



# FFR after Recent MI (Culprit Vessel)

*Comparison of FFR in 57 patients with an MI  $\geq 6$  days old to SPECT imaging before and after PCI*



	MIBI + n = 40	MIBI - n = 40
FFR $\geq$ 0.75 n = 45	5	40
FFR<0.75 n = 35	35	0

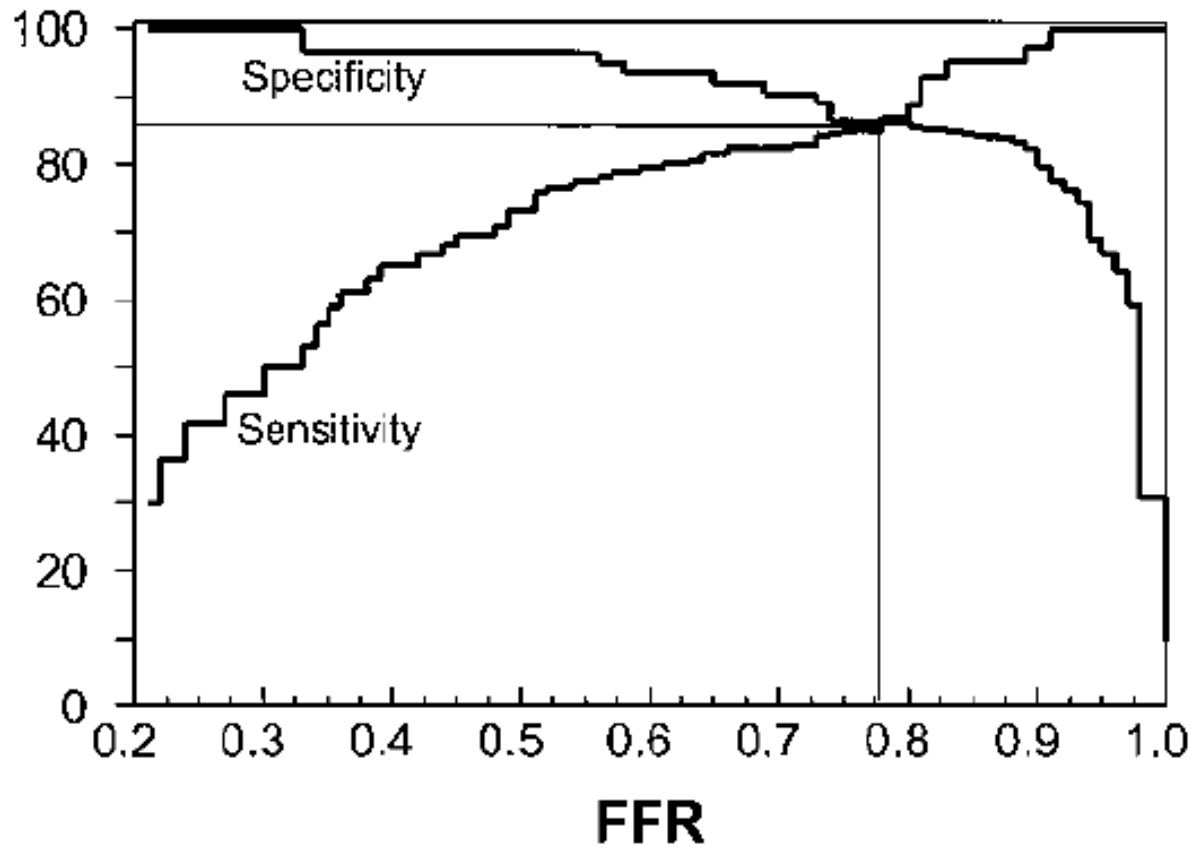
Concordance = 94%

$\kappa = 0.87$ ;  $P < 0.0001$



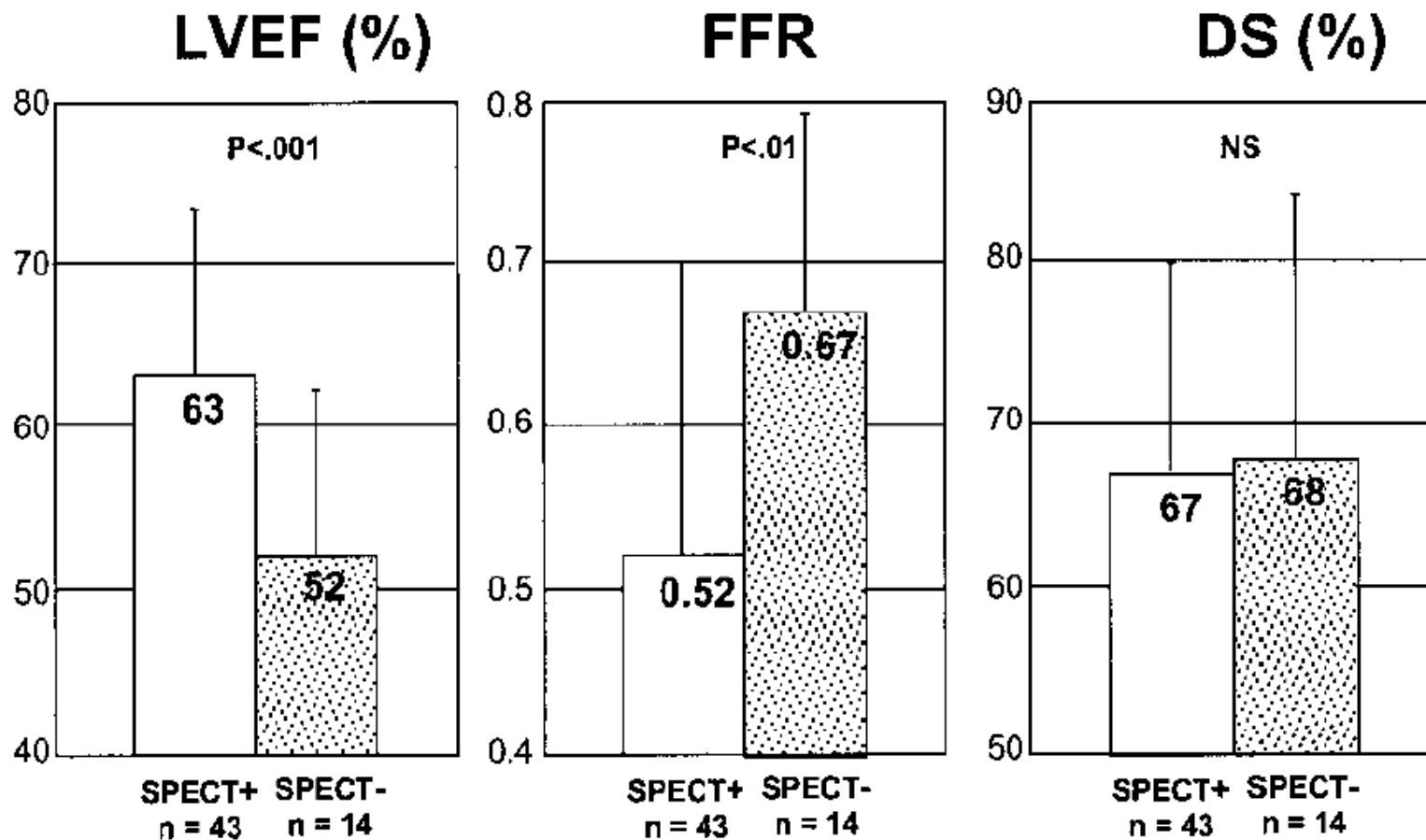
# FFR after Recent MI (Culprit Vessel)

*Ideal FFR cutoff in the setting of old MI*



# FFR after Recent MI (Culprit Vessel)

*Relationship between FFR and mass of myocardium at risk*

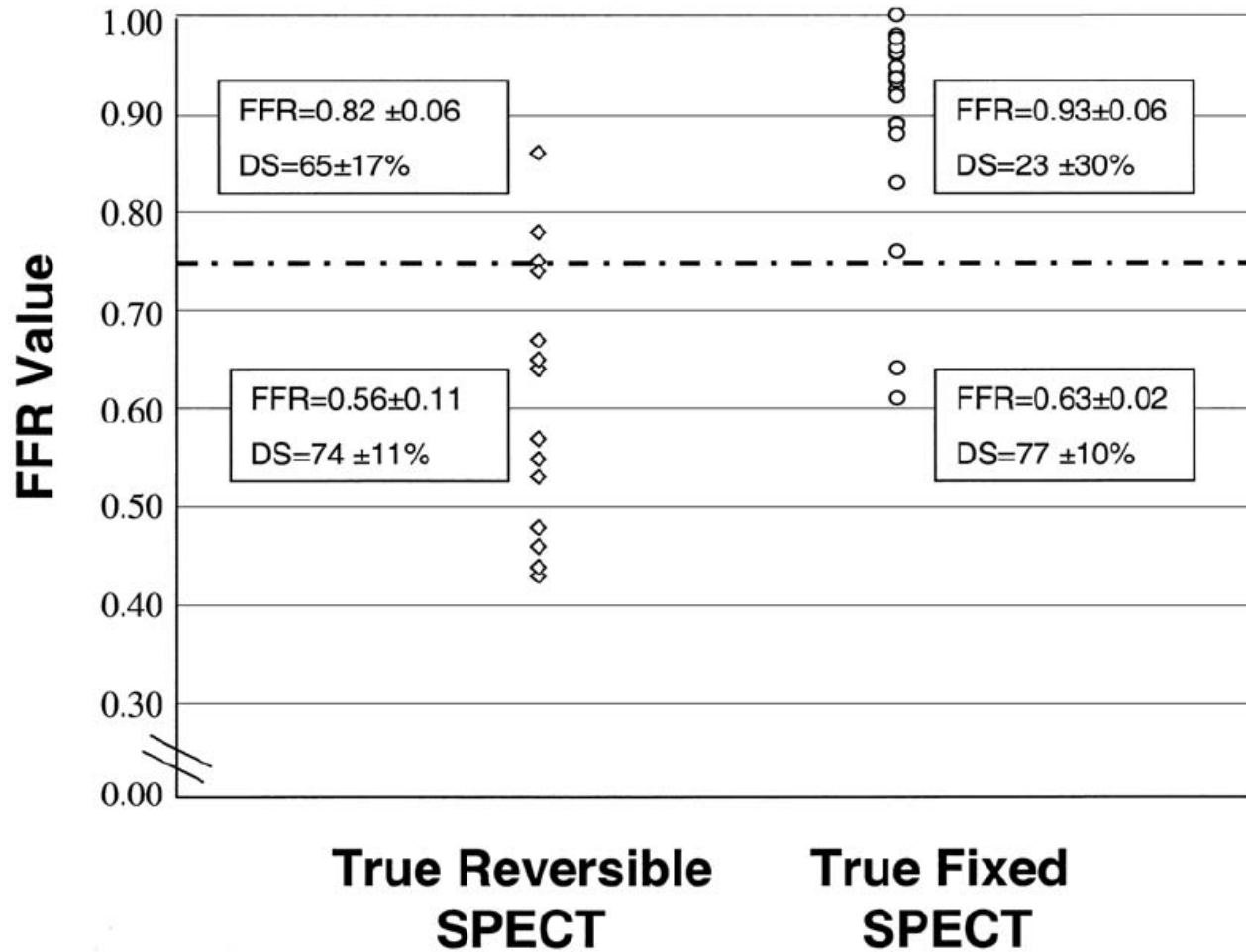


# FFR after Recent MI (Culprit Vessel)

- FFR and SPECT performed in 48 patients 3.7 days after MI
  - 73% had STEMI and had to be  $\geq 3$  days;  $\geq 2$  days for NSTEMI
- 23 patients also had myocardial contrast echo
- Follow-up SPECT was performed 11 weeks later to identify true positive and negatives

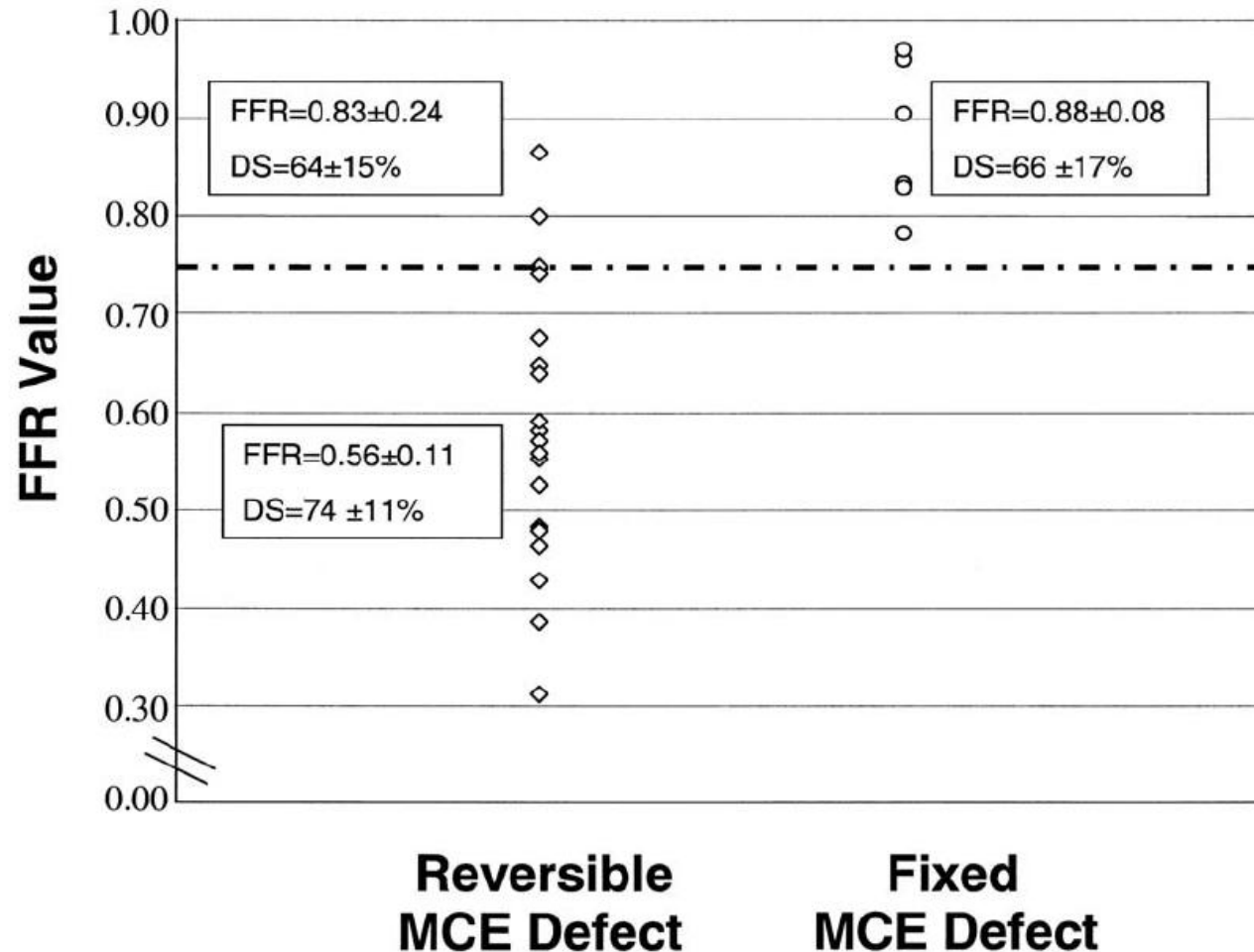


# FFR after Recent MI (Culprit Vessel)



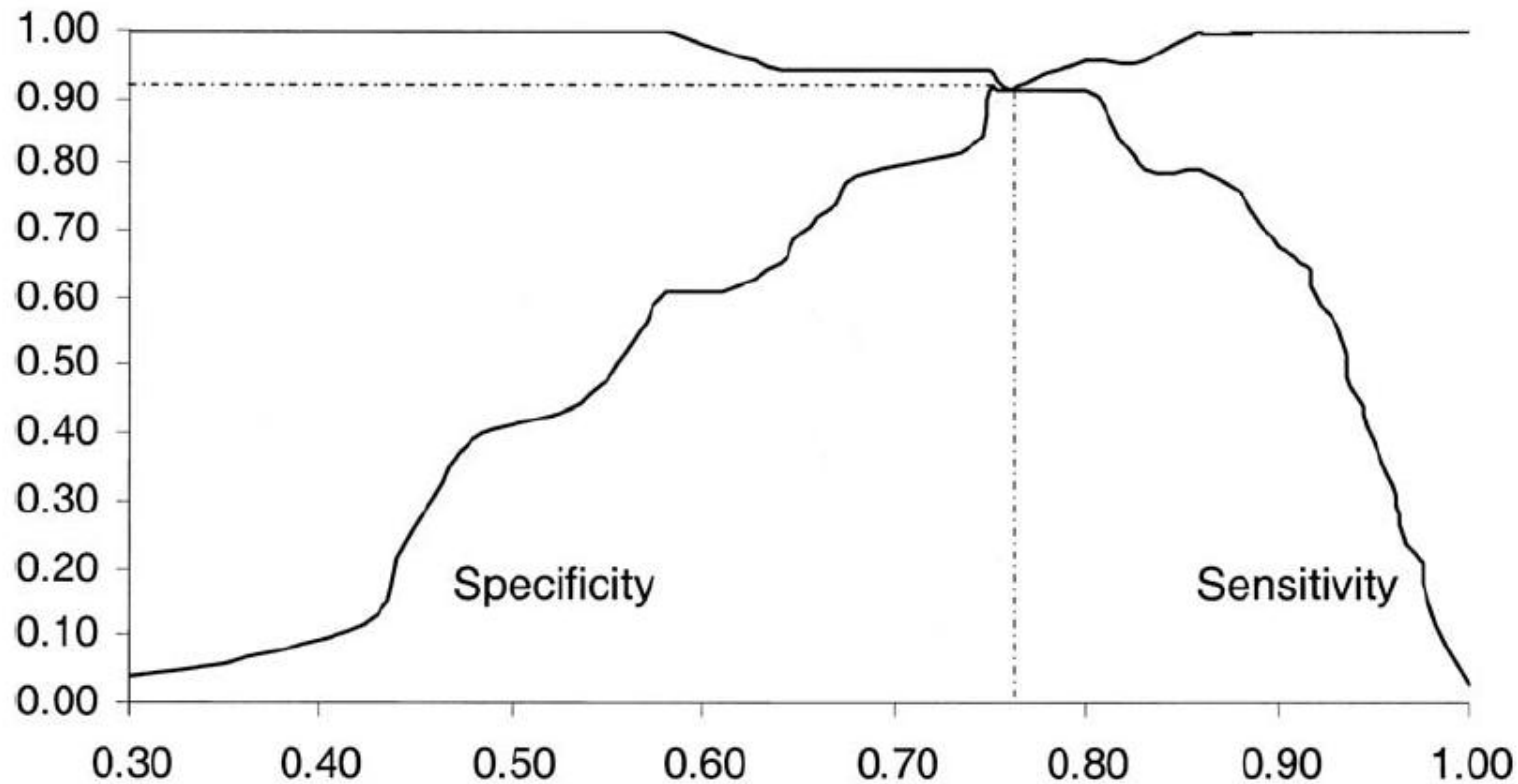


# FFR after Recent MI (Culprit Vessel)



# FFR after Recent MI (Culprit Vessel)

***Best FFR Cutoff is 0.78***



# FFR during/after STEMI (Culprit Vessel)

- How long do you have to wait for “microvascular stunning” to resolve and before you can get a reproducible FFR?
- Likely the time to recovery of the microvasculature is variable, depending on the size of the infarct, and can be as short as days, and as long as a week, or longer...



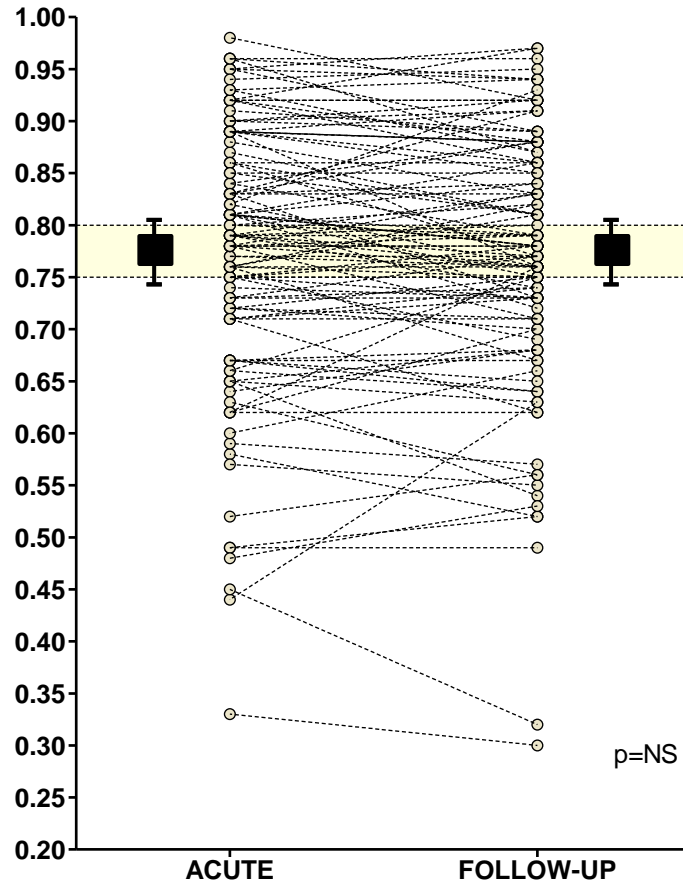
# FFR STEMI (Non-Culprit Vessels)

- During acute STEMI, is FFR measurement of non-culprit vessels reliable?



# FFR STEMI (Non-Culprit Vessels)

*101 patients with an acute coronary syndrome (75 STEMI, 26 NSTEMI)  
112 non culprit stenoses FFR measured acutely and 35±24 days later*



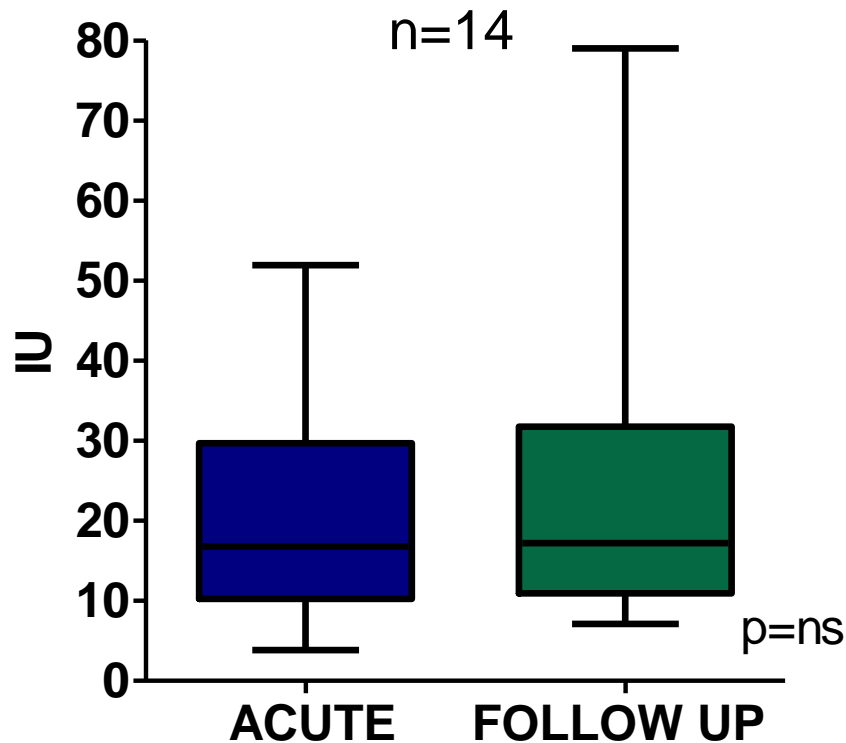
*In only 2/112  
stenoses was the  
FFR >0.80 during the  
ACS and <0.75 at  
follow-up.*



# FFR STEMI (Non-Culprit Vessels)

*Microvascular resistance did not change from baseline to follow-up*

Index of Microcirculatory resistance



# FFR during NSTEMI

- Can we measure FFR in non ST elevation acute myocardial infarction?
  - In the culprit vessel?
  - In the non-culprit vessel?



# FFR in NSTEMI ACS (Culprit Vessel)

***70 patients with ACS and an intermediate lesion  
randomized to FFR or stress perfusion scan***

	Group 1 (SPS) (n = 35)	Group 2 (FFR) (n = 35)
Age	55 ± 4	59 ± 6
Gender M/F	22/13	24/11
EF	53 ± 4	50 ± 4
MI without ST-segment elevation (n)	24	20
ST-segment changes (n)	16	14
ST-segment changes or T-wave changes (n)	20	18
Prior coronary artery disease	14	9
Hypertension (n)	26	25
Diabetes mellitus (n)	11	13
Hyperlipidemia (n)	22	19
Tobacco abuse (n)	15	20
Lesion		
Left anterior descending (n)	13	15
Circumflex (n)	10	9
Right coronary artery (n)	12	11
Minimal lumen diameter (mm)	1.51 ± 0.1	1.43 ± 0.1
Reference lumen diameter (mm)	3.1 ± 0.2	2.88 ± 0.2
% Diameter stenosis	49 ± 2	48 ± 2





# FFR in NSTEMI ACS (Culprit Vessel)

## *Clinical Events at 1 Year Follow-Up*

	Group 1 (SPS) (n = 34)	Group 2 (FFR) (n = 34)
Average follow-up (months)	12.0 ± 0.8	14.0 ± 1.0
Death	0	0
Angina		
No angina (n)	17	24
CCS classification of angina (n)		
1-2	17	10
3-4 (admitted to the hospital)	6	5
Stress perfusion scintigraphy	4	4
Negative (n)	4	4
Cardiac catheterization	2	3
Results (no change)	2	2
Disease progression	0	1
MI	1	1
CABG including target vessel	1	2
PCI	0	0

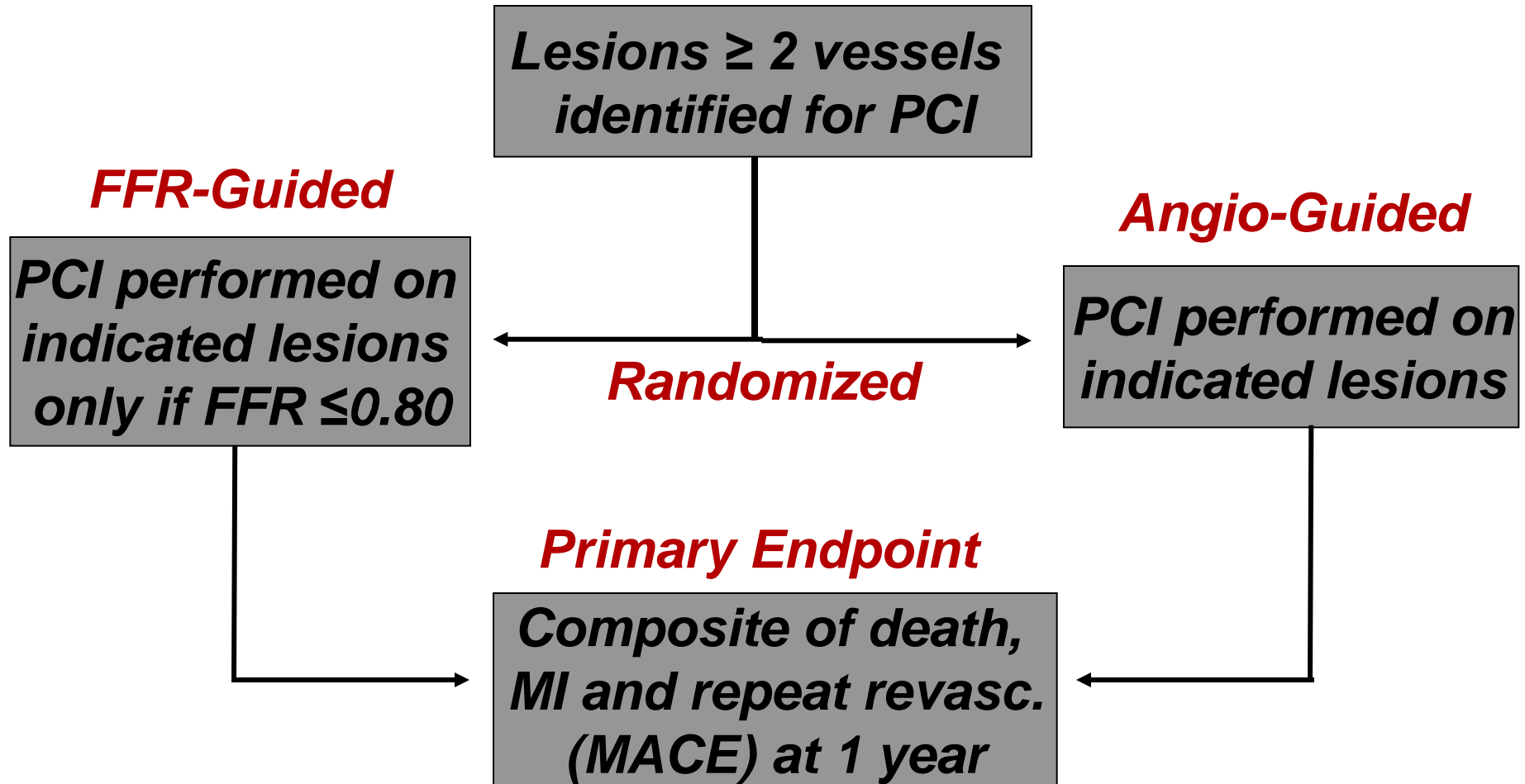


# FFR NSTE ACS (Culprit + Non Culprit Vessel)

**F**ractional Flow Reserve *versus*  
**A**ngiography for  
**M**ultivessel  
**E**valuation



# FAME Trial:



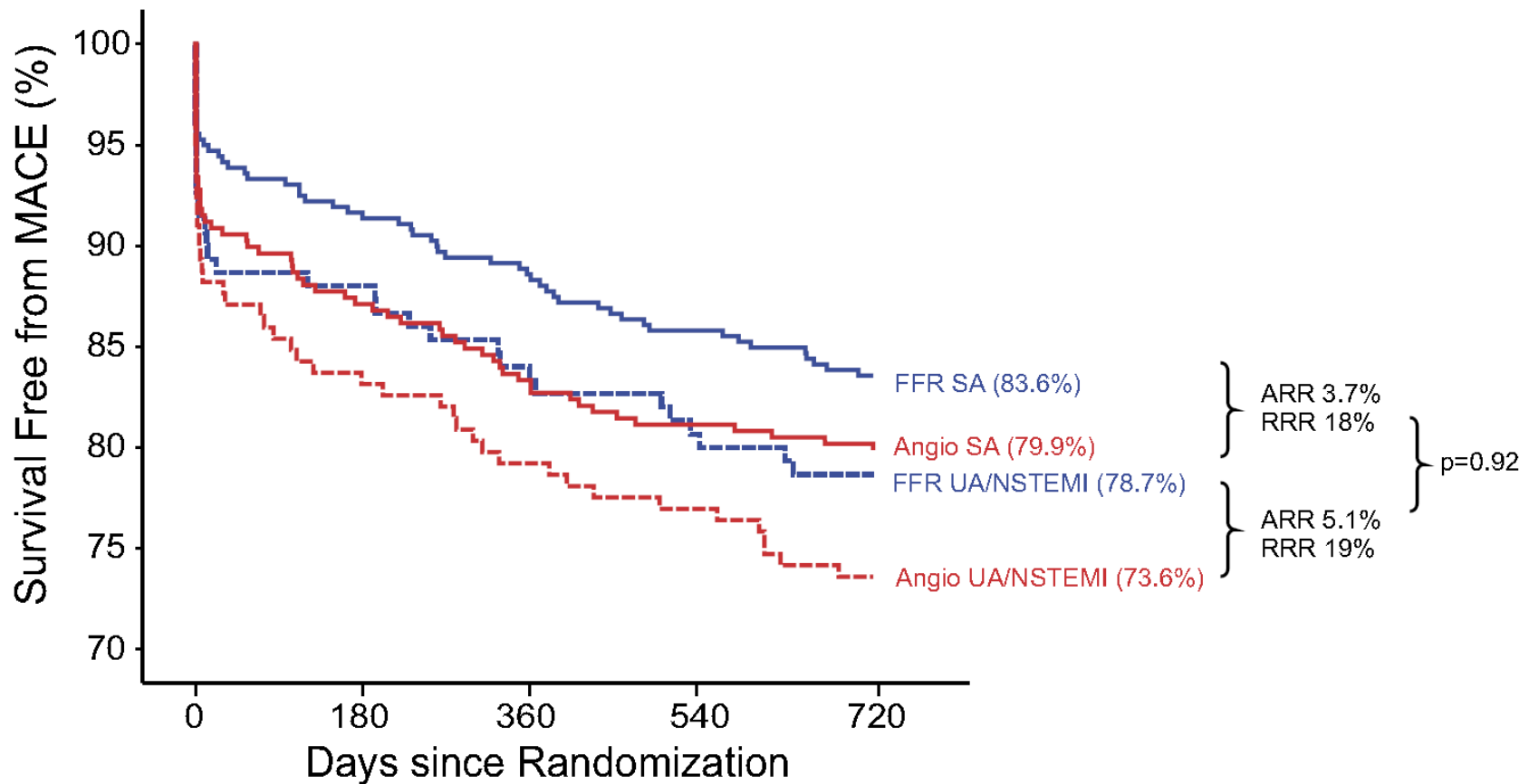
# Baseline Characteristics

	Angio- Guided n = 496	FFR- Guided n = 509	P Value
Age, mean $\pm$ SD	64 $\pm$ 10	65 $\pm$ 10	0.47
Male, %	73	75	0.30
Diabetes, %	25	24	0.65
Hypertension, %	66	61	0.10
Current smoker, %	32	27	0.12
Hyperlipidemia, %	73	72	0.62
Previous MI, %	36	37	0.84
<b>NSTE ACS, %</b>	<b>36</b>	<b>29</b>	<b>0.11</b>
Previous PCI, %	26	29	0.34
LVEF, mean $\pm$ SD	57 $\pm$ 12	57 $\pm$ 11	0.92
LVEF < 50%, %	27	29	0.47

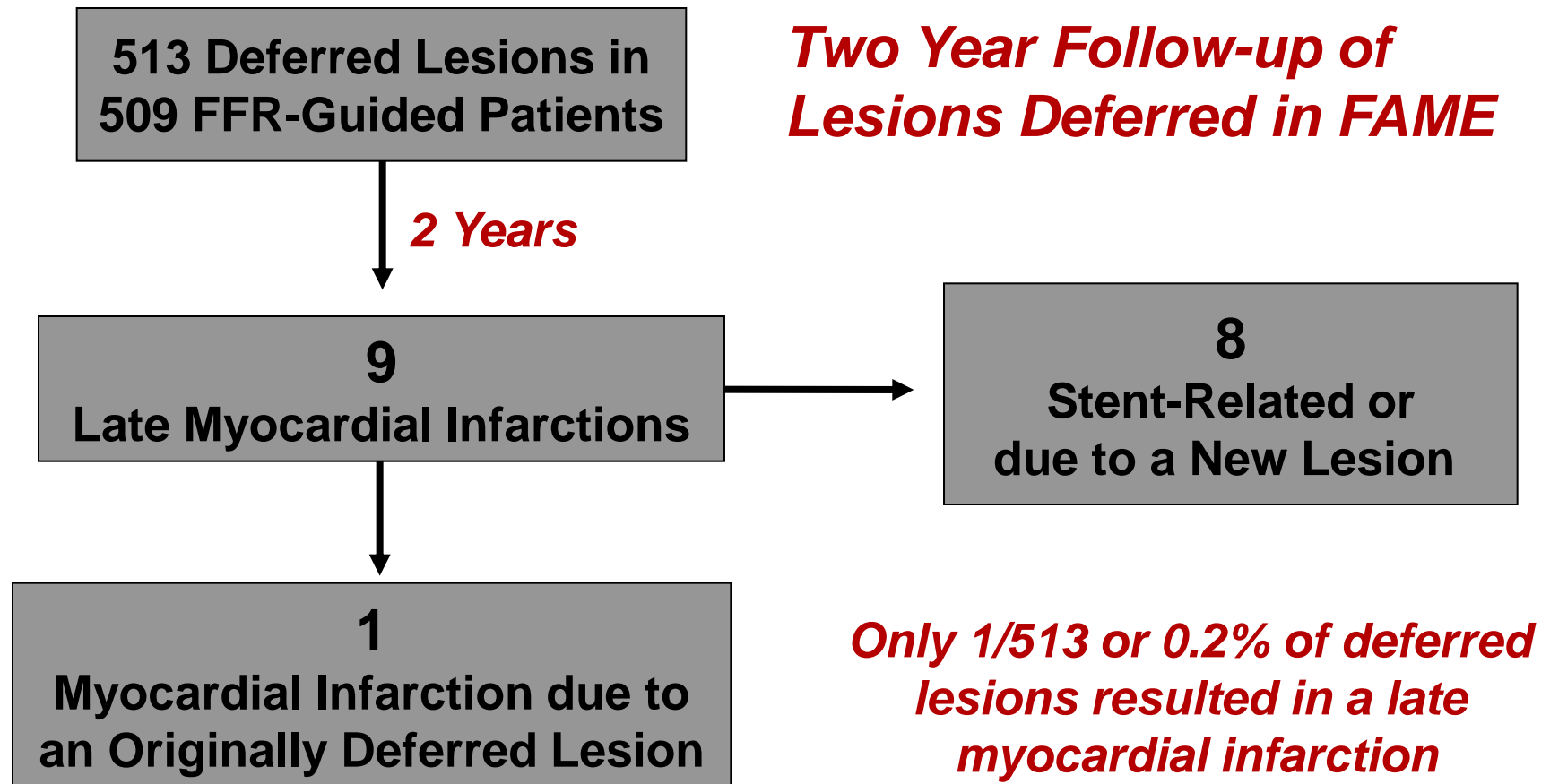


# FFR NSTE ACS (Culprit + Non Culprit Vessel)

## Comparison of MACE in FAME patients with and without ACS



# What happens to deferred lesions?



# FFR in Acute Coronary Syndromes

## *Take Home Messages:*

- FFR of the culprit vessel may be unreliable in the setting of STEMI, but can be accurately measured in the non-culprit vessel
- In a less acute MI setting, once microvascular stunning has decreased, FFR at a cut-point of 0.75-0.80 remains accurate
- For a given stenosis, FFR correlates inversely with the mass of viable myocardium supplied
- FFR appears accurate and safe in the setting of NSTEMI ACS for both culprit and non-culprit vessels



# Summary

## *Indications for FFR in Acute Coronary Syndromes*

	Culprit Vessel	Non-Culprit Vessel
STEMI (acute)	-	+
STEMI (chronic)	+	+
Non ST Elevation ACS	+	+

