Ischemia-Guided Optimal Revascularization

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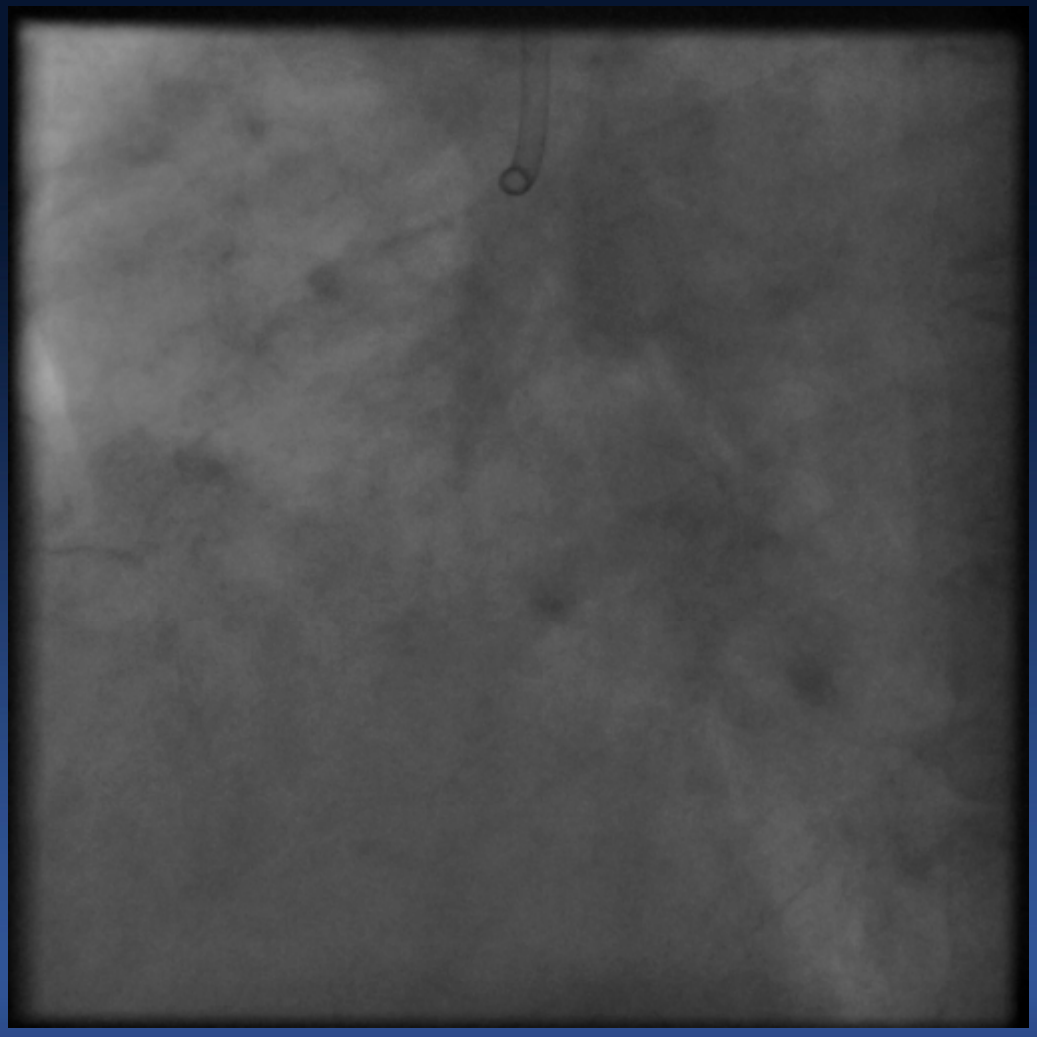
Multivessel (Multilesion) CAD

- ACS patients : consensus
  - Culprit-lesion intervention followed by function-guided non-culprit revascularization
- Stable angina patients :debated
  - Complete vs. Incomplete
  - Anatomy-guided vs. Function-guided

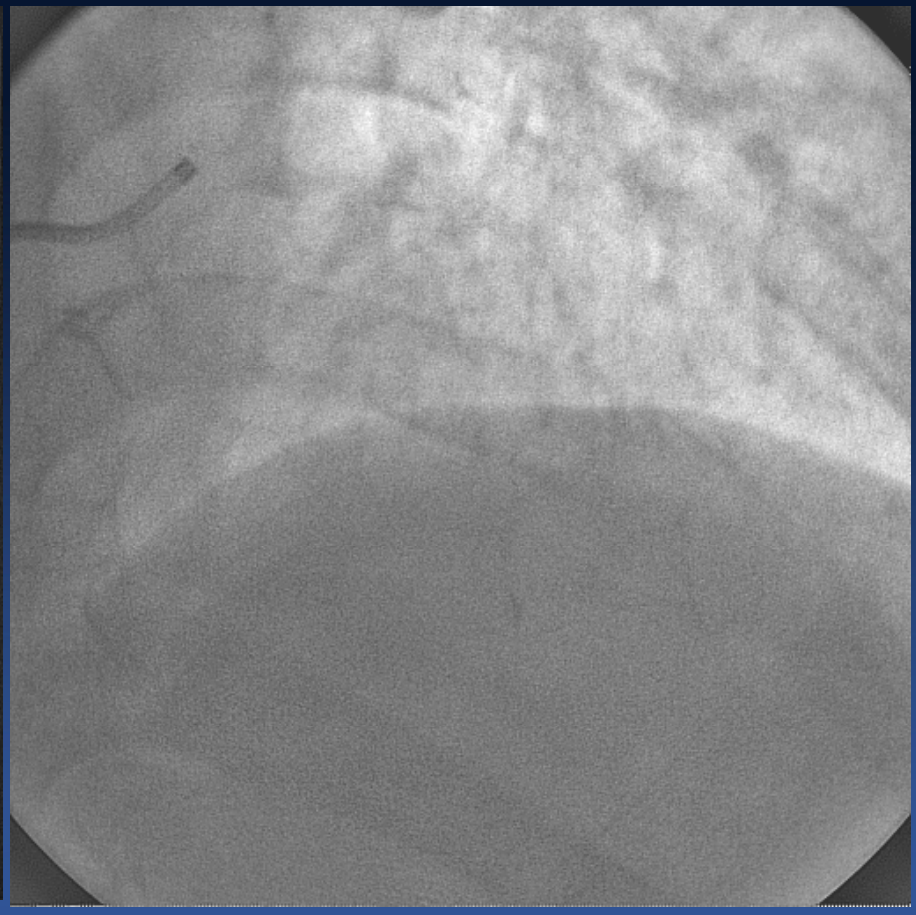
Case: Stable Angina

- F / 72
- Recent onset chest pain for 1 month
- Multiple stenosis including LM by coronary CT in another hospital
- Normal EKG
- Normal echocardiography with 65% of LV EF
- Good exercise performance before symptom
- No coronary risk factor

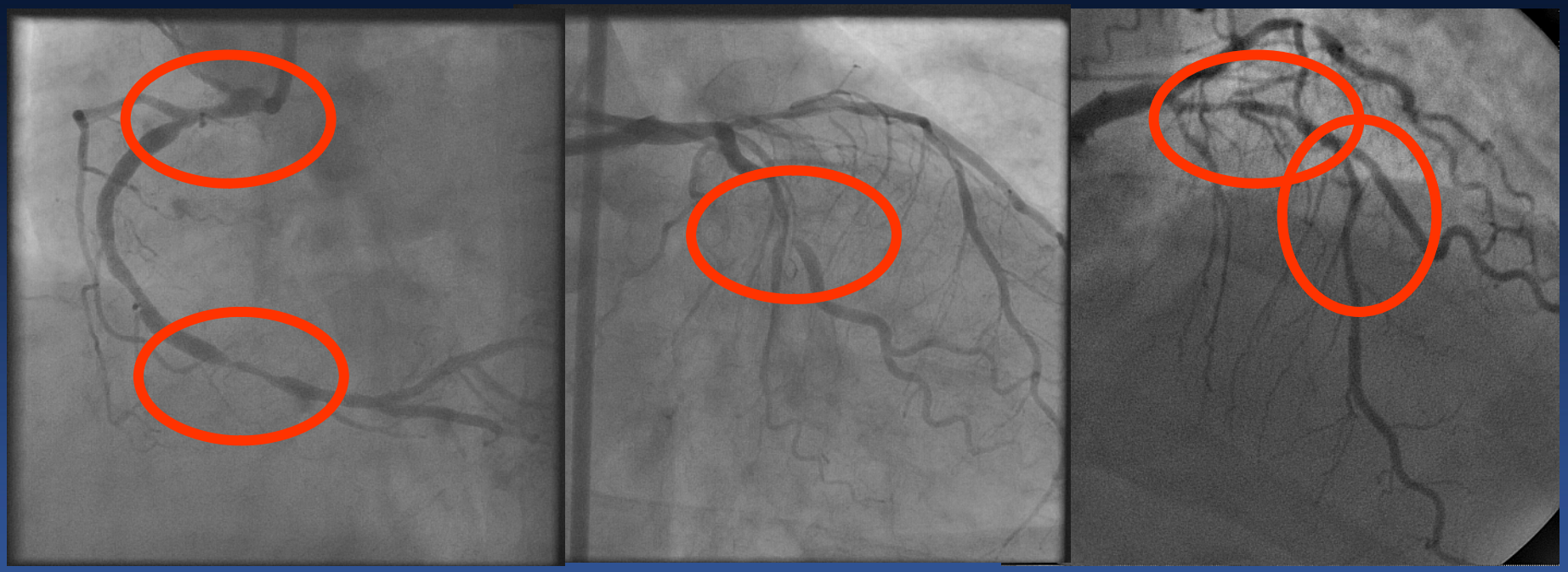
Coronary Angiogram



Coronary Angiogram

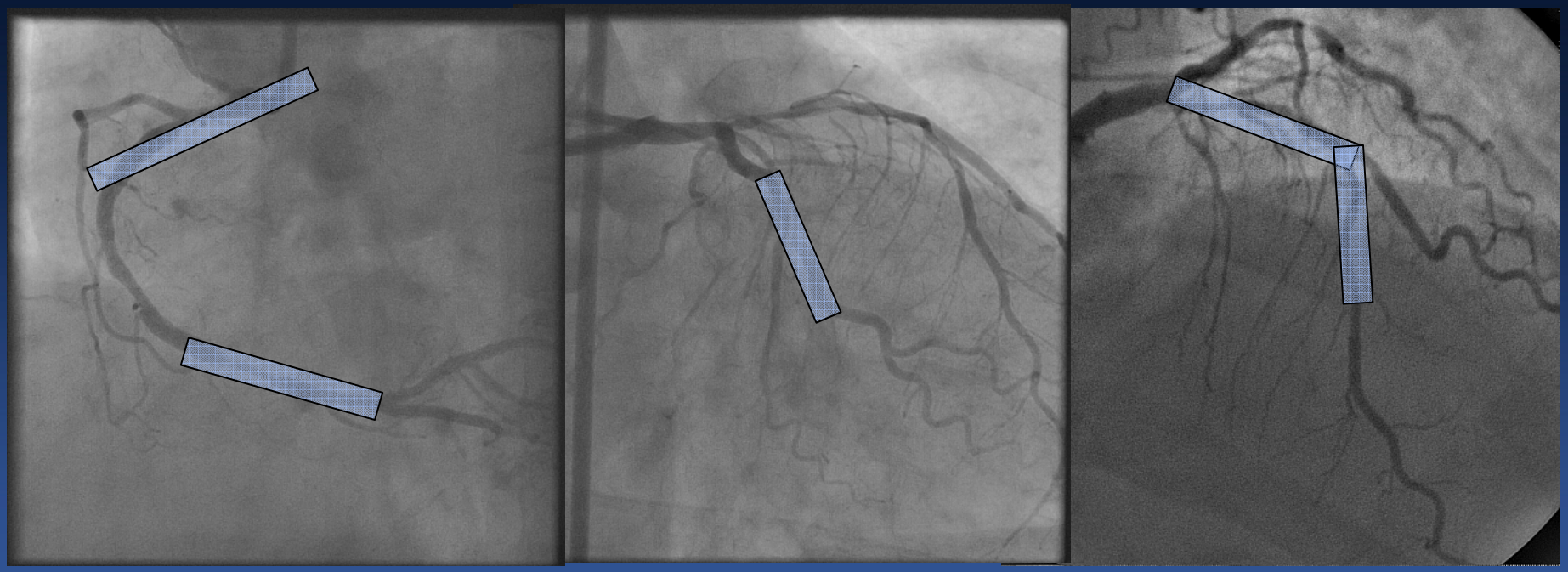


Coronary Angiogram
SYNTAX Calculation = 24



Simulation

Complete Revascularization using at least 5 stents



ESC 2011 and ACC 2011 Update
PCI vs. CABG

	<< CABG		<< PCI	
Subset of CAD by anatomy	**ESC**	**ACC**	**ESC**	**ACC**
1VD or 2VD – non-proximal LAD	**IIbC**	**IIa B**	**IC**	**IIb B**
1VD or 2VD – proximal LAD	**IA**	**IA**	**IIa B**	**IIa B**
3VD simple lesions, full functional revascularization achievable with PCI,SYNTAX score>22	**IA**	**IB**	**IIa B**	**IIb B**
3VD complex lesions, incomplete revascularization achievable with PCI,SYNTAX score>22	**IA**	**-**	**III A**	**-**
Left main (isolated or 1VD, ostium/shaft)	**IA**	**IB**	**IIa B**	**IIa B**
Left main (isolated or 1VD, distal bifurcation)	**IA**	**IB**	**IIb B**	**IIb B**
Left main + 2VD or 3VD, SYNTAX score≤32	**IA**	**IB**	**IIb B**	**IIb B**
Left main + 2VD or 3VD, SYNTAX score≥33	**IA**	**IB**	**III B**	**III B**

Predictors of Mortality in the CASS Registry (CABG Patients)

Predictors of Mortality
CHF Score
LV Wall Motion Score
Number of Assoc Diseases
Age
Number of Prox Vessels Diseased
LVEDP
Unstable Angina
<3 Vessels Bypassed

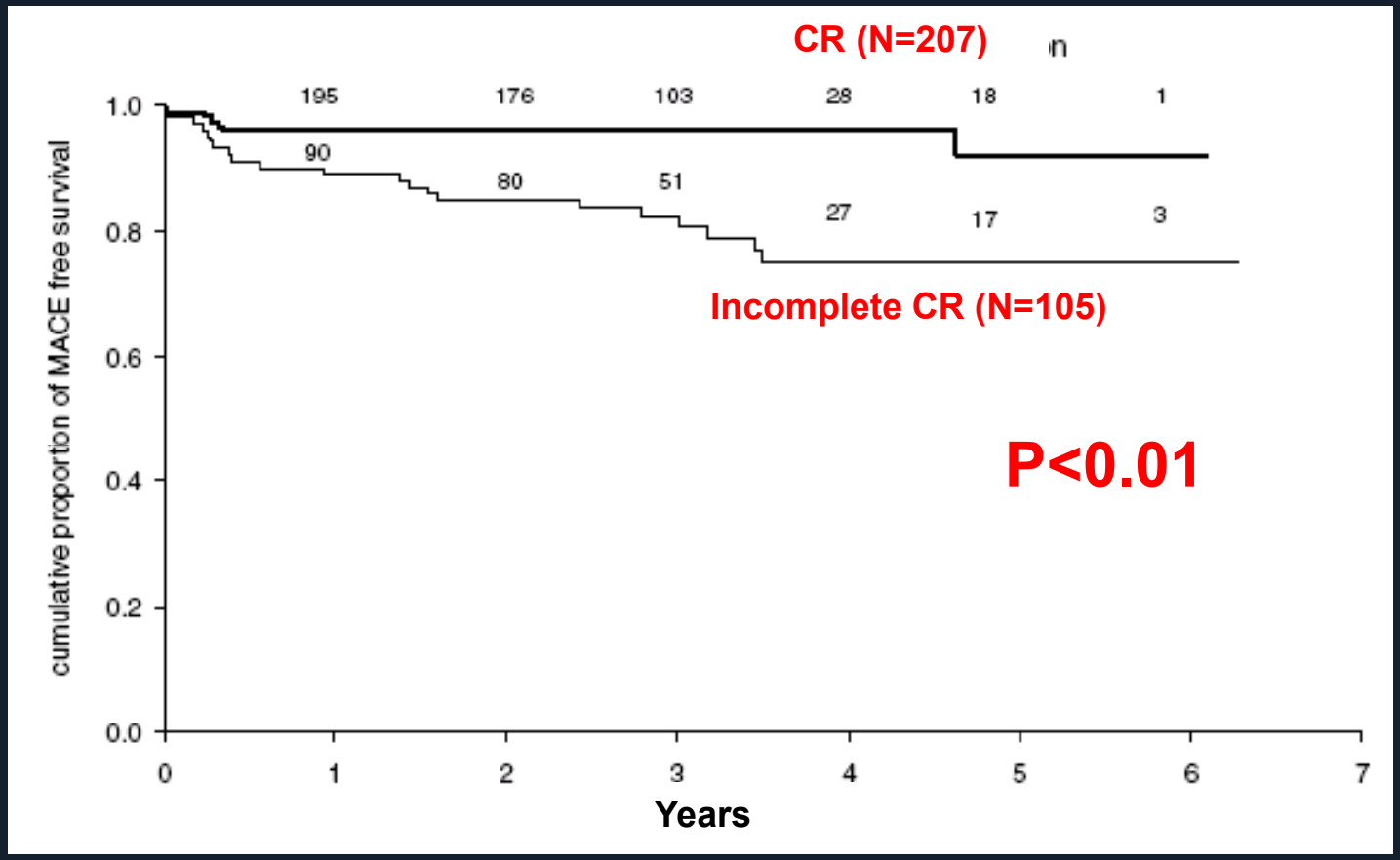
CR was associated with the greatest improvements in outcome among:

- *Pts with more severe angina*
- *Pts with reduced LV function*

Bell et al, Circulation 1992

Impact of CR after CABG Surgery

For Death, UA, MI, Hospitalization, & Repeat revascularization -free Survival

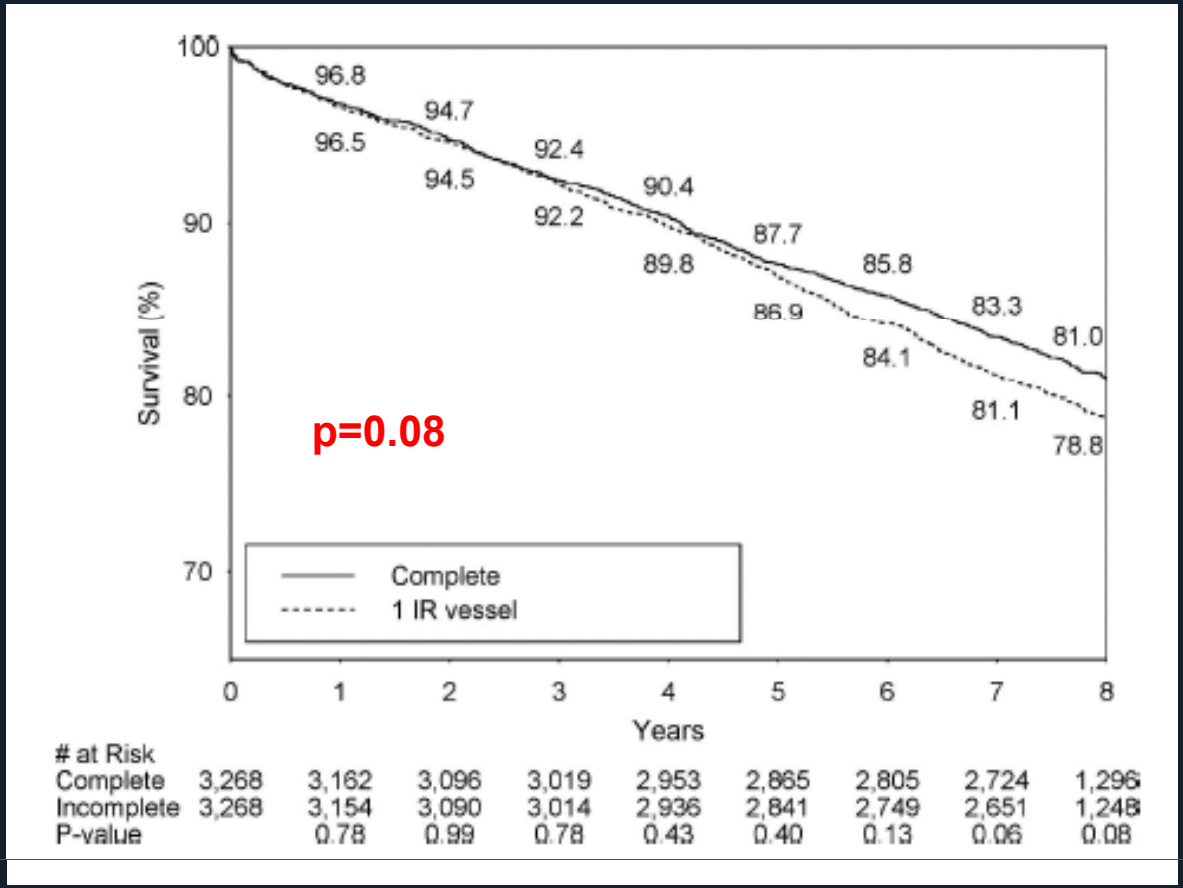


Agostini M et al. J Card Surg 2009;24:650

NY State PCI Database (1999-2000)

Impact of CR for Mortality in BMS Era

Propensity Matching from 13,016 Pts



Wu C et al, *Circ Cardiovasc Interv. 2011;4:413*

NY State PCI Database (2003-2004)

Impact of CR for Mortality in DES Era

Revascularization was Incomplete in 69%

	N	Adjusted HR of IR compared with CR
CR	3499	
IR (All)	7795	1.23 (1.04,1.45)
1 IR with no CTO	3815	1.23 (1.02,1.48)
1 IR vessel is CTO	1725	1.11 (0.87,1.42)
≥2 IR, no CTO	1233	1.18 (0.89,1.56)
≥2 IR, ≥1 CTO	1022	1.44 (1.14,1.82)

Hannan EL et al, *JACC: Cardiovasc Intv 2009*

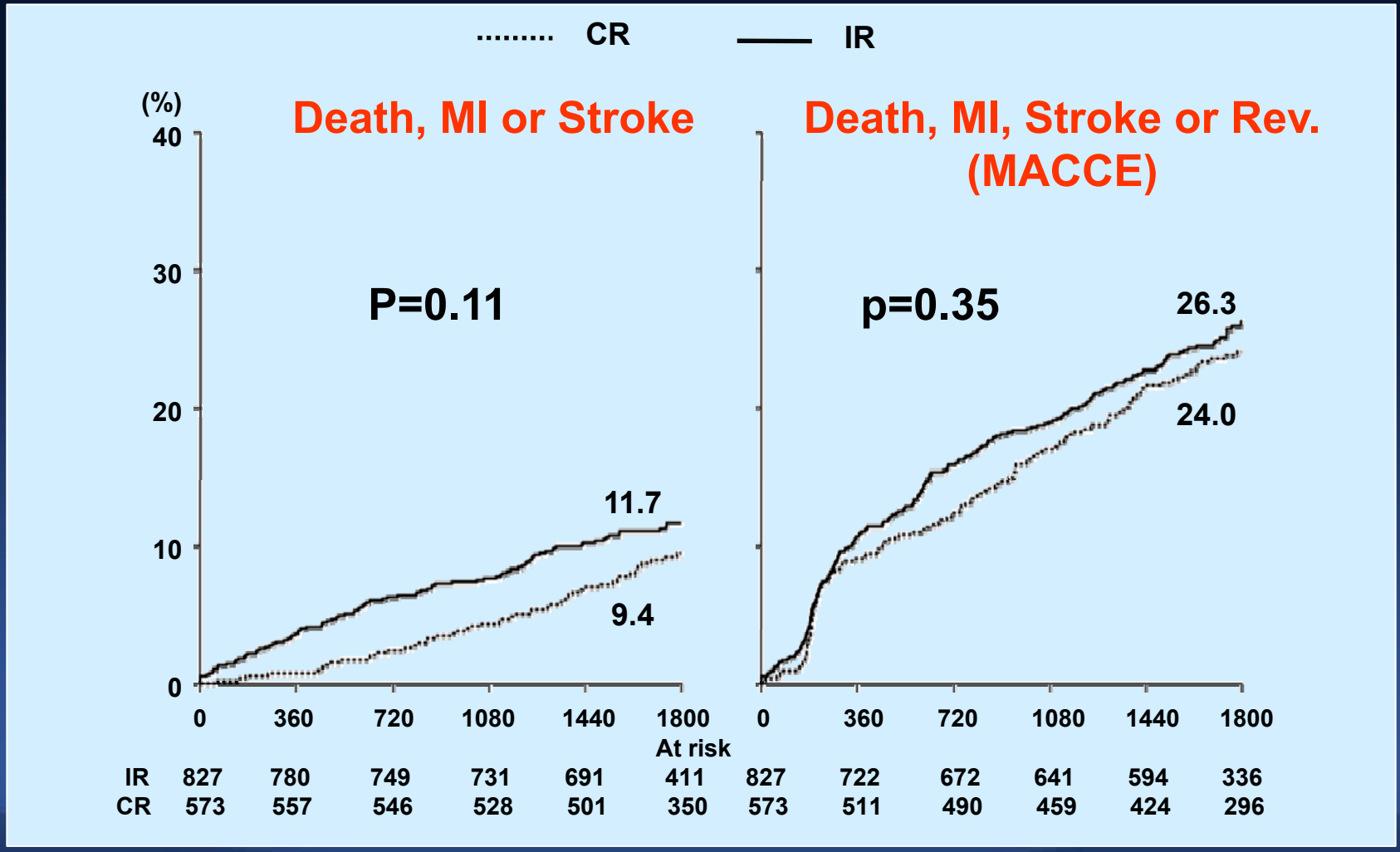
Debate about this issue of CR

Hardly answer properly because…

- Various definitions about CR
- Different outcomes according to the diverse clinical presentations
- Heterogeneous patient's characteristics
- Mostly observational data, no randomized study

Angiographic CR improves prognosis?

1914 Angina MVD (1400 PCI, 514 CABG) in Asan Multivessel Registry



Kim YH et al. Circulation. 2011;123:2373

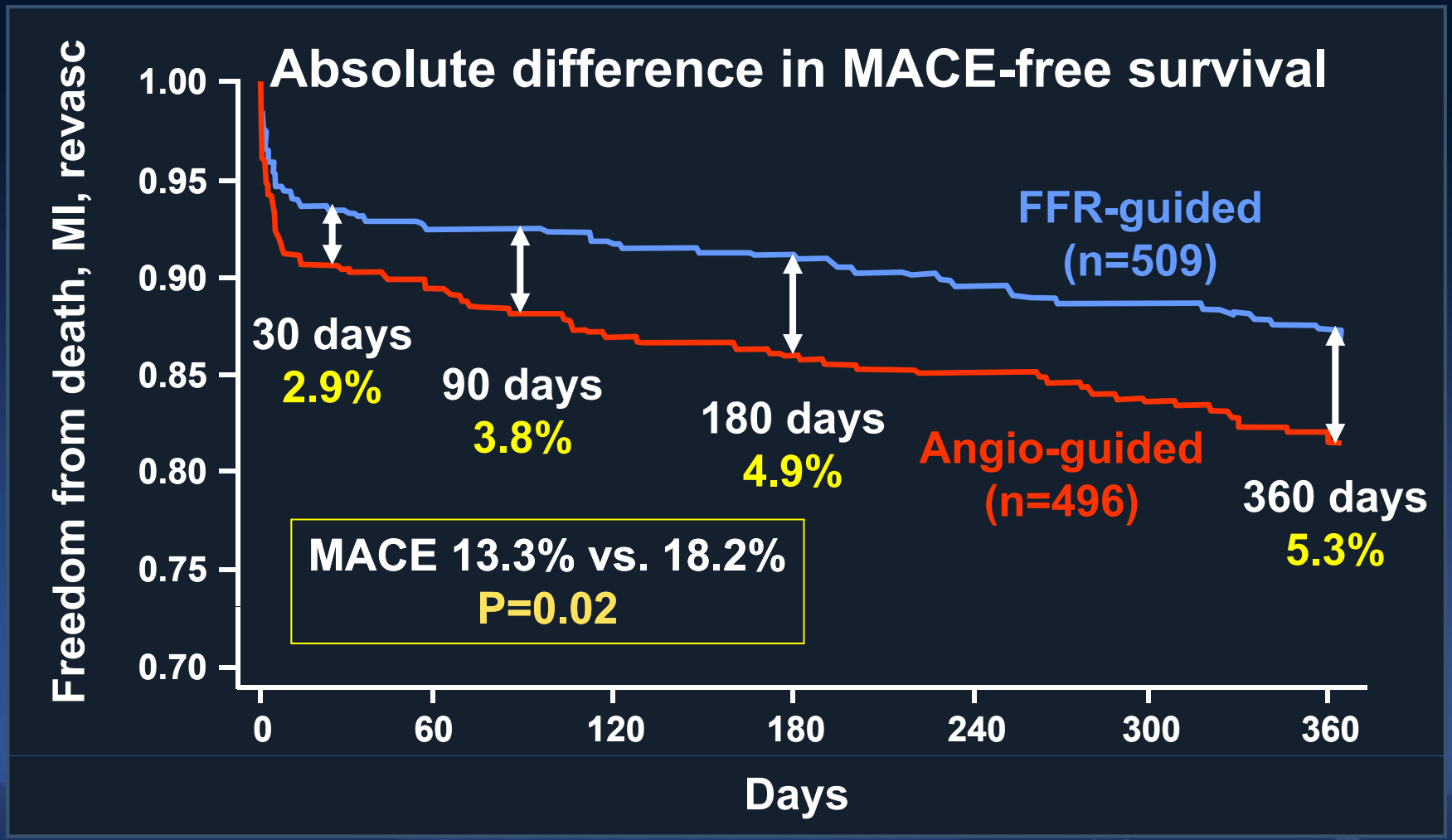
Adjusted Outcomes of MACCE

Definitions	Adjustment using inverse-probability-of-treatment weighting			
	HR	95% CI		p
		LL	UL	
Angiographic CR-1 (≥ 1.5 mm vessel)	0.91	0.75	1.10	0.32
Angiographic CR-2 (≥ 2.5 mm vessel)	0.92	0.76	1.12	0.40
Proximal CR (proximal segment)	0.90	0.74	1.10	0.30

No interaction was found between the treatment type and any definition of CRs.

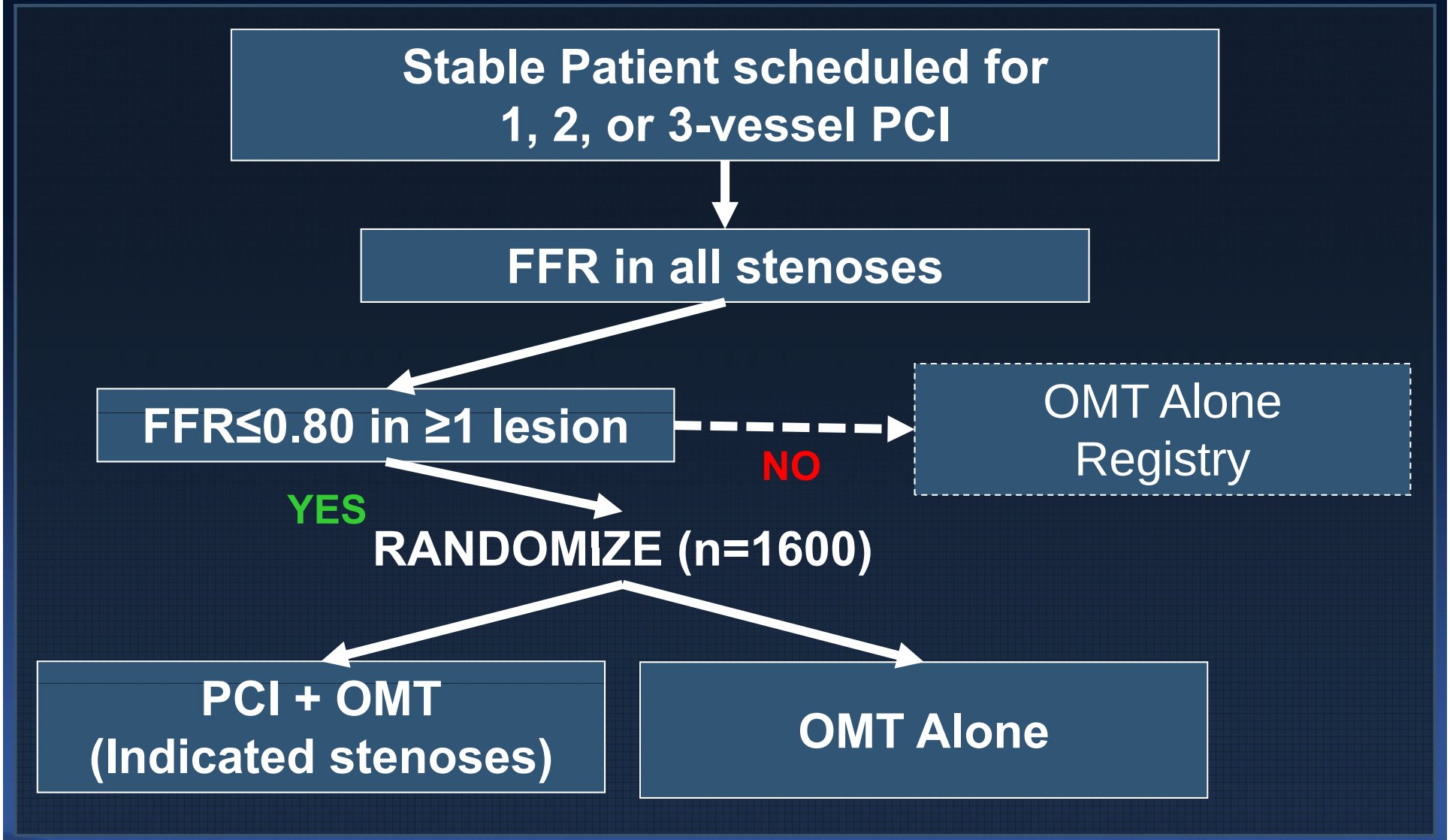
FAME : FFR-guided PCI

1005 pts with MVD undergoing PCI with DES were randomized to FFR-guided vs. angio-guided intervention



Tonino PAL et al. *NEJM* 2009;360:213–24

FAME II : FFR-guided PCI vs. OMT



FFR-guided PCI reduced urgent revascularization than OMT

FFR shows benefit in FAME II; enrollment halted

JANUARY 18, 2012 Lisa Nainggolan

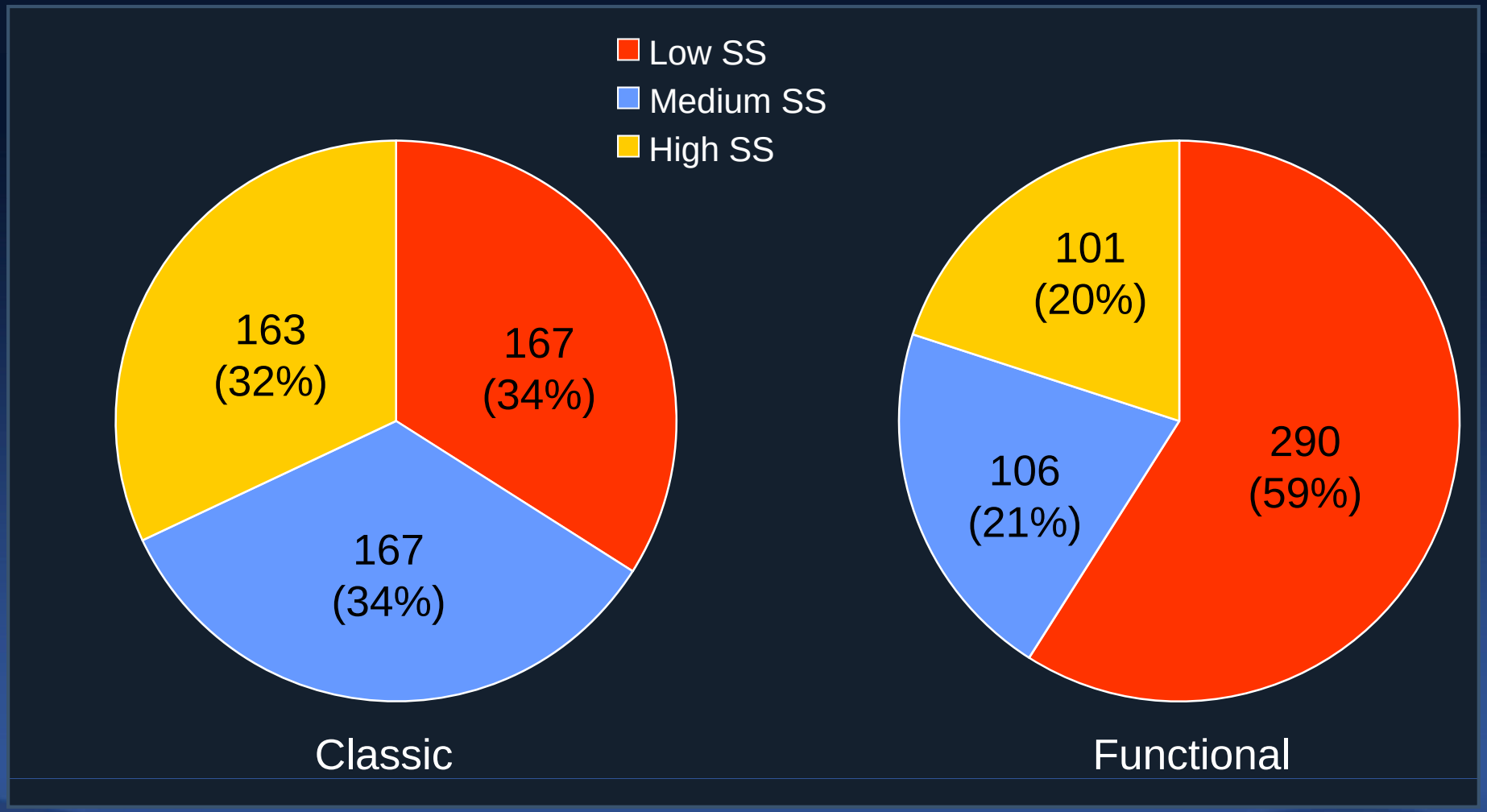
St Paul, MN - An interim analysis of the FAME II study— which is comparing fractional-flow-reserve (FFR)-guided stenting with optimal medical treatment (OMT) compared with OMT alone—has shown a clear benefit of the FFR-guided approach and, as a result, the independent data safety monitoring board (DSMB) has recommended that patient enrollment be stopped [**1**]. "The DSMB considers it unethical to continue to randomize patients to OMT alone," notes St Jude Medical in a statement.

The analysis revealed a statistically significant reduction in the need for hospital readmission and urgent revascularization when FFR-guided assessment was used to direct treatment in patients with coronary artery disease (CAD) in FAME II, it adds.

FFR is a physiological index used to determine the hemodynamic severity of narrowings in the coronary arteries and is measured using St Jude Medical's **PressureWire Aeris** and **PressureWire Certus**. FFR specifically identifies which narrowings are responsible for obstructing the flow of blood to the heart and guides the interventional cardiologist in determining which lesions warrant stenting, "resulting in improved patient outcomes and reduced healthcare costs," the company notes.

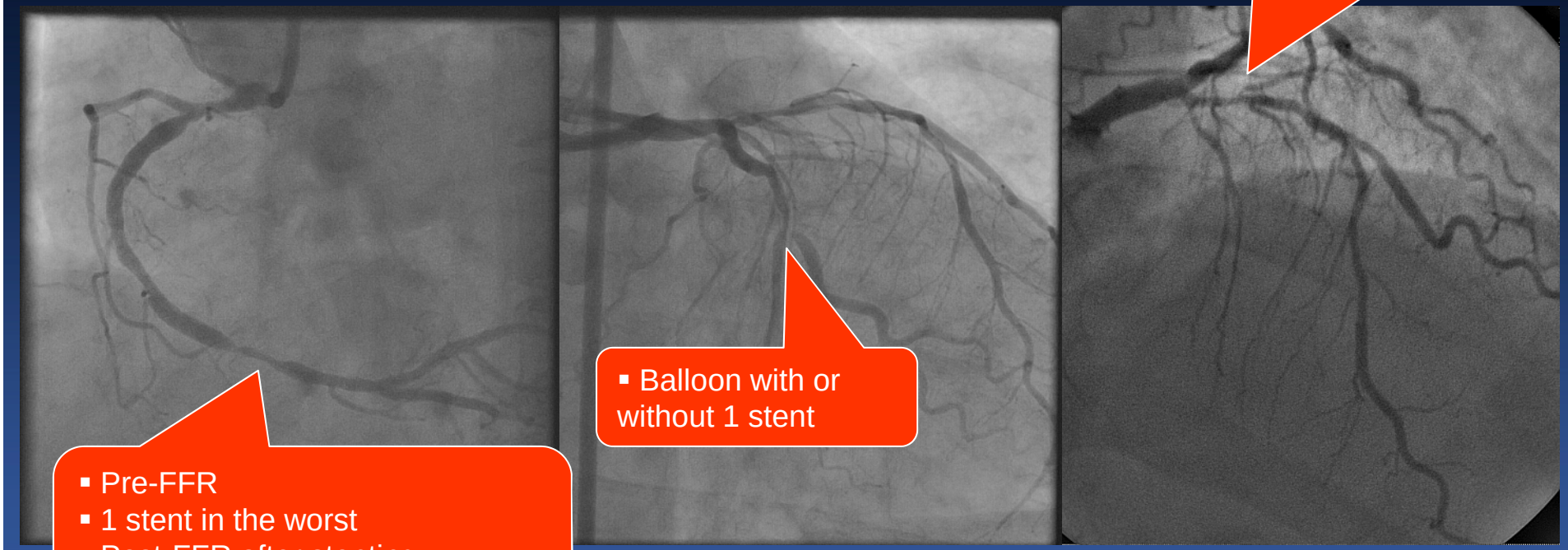
FAME II has randomized 1219 patients with stable CAD in 28 centers in Europe, the US, and Canada; those who are already participating will continue to be followed according to the trial protocol, but no new patients will be enrolled. Currently, there is no difference in the rates of death or MI between the two study arms, says St Jude, noting that initial results from the trial will be presented this year.

Anatomical CR is not necessary for a good outcome of PCI !



Nam et al, JACC 2011;58:1211-18

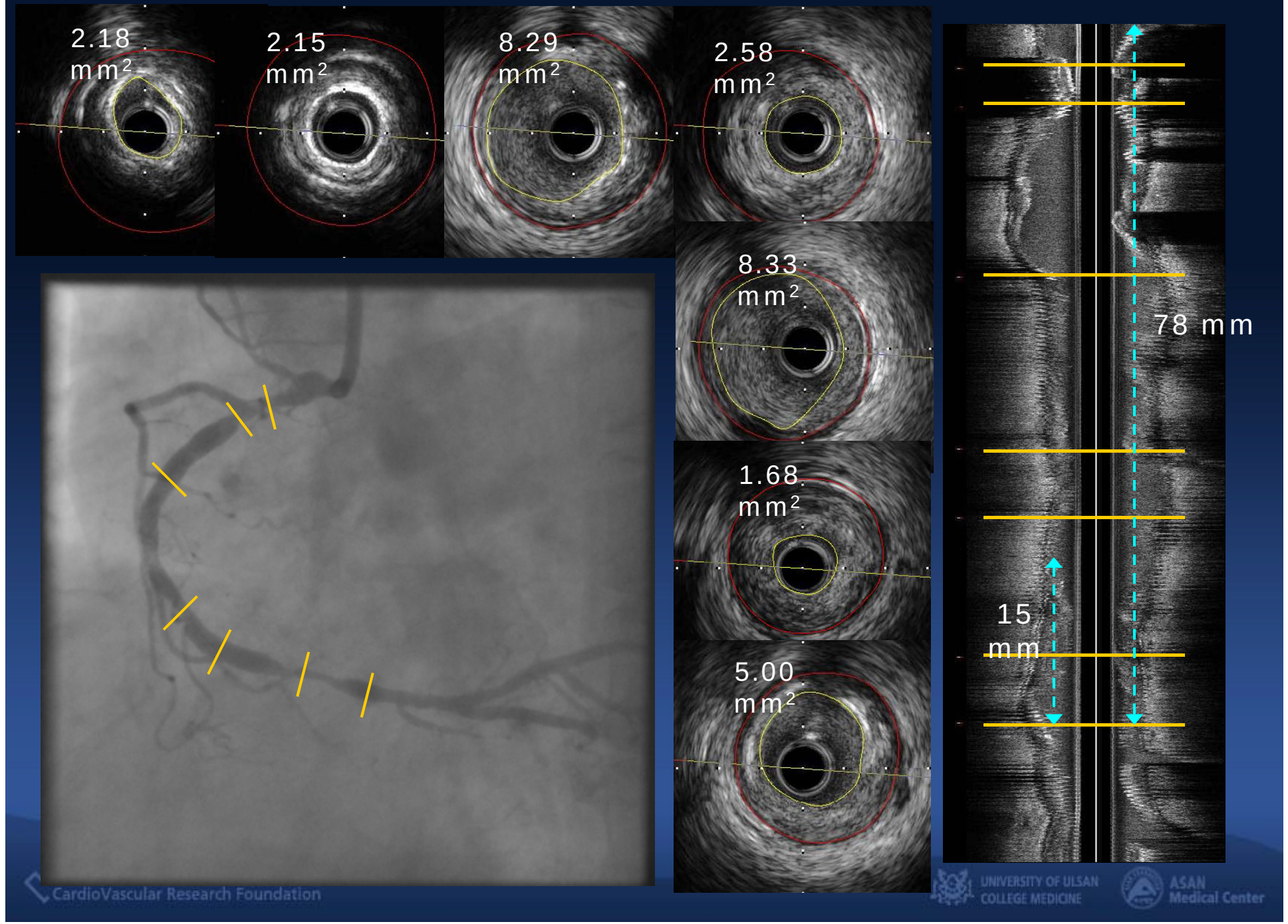
Function-guided Reasonable Incomplete Revascularization



- Pre-FFR
- 1 stent in the worst
- Post-FFR after stenting
- 1 stent in other LAD if p-FFR ≤ 0.75

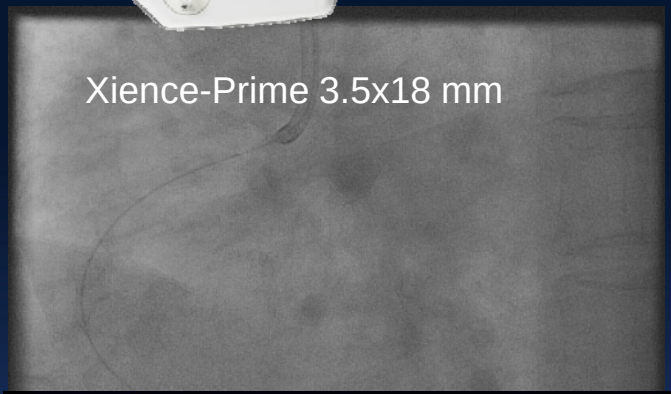
- Balloon with or without 1 stent

- Pre-FFR
- 1 stent in the worst
- Post-FFR after stenting
- 1 stent in pRCA if p-FFR ≤ 0.75

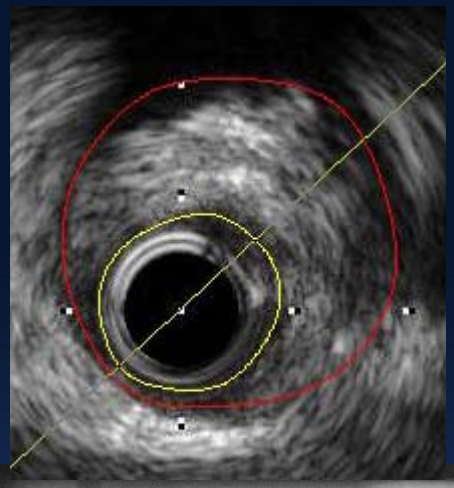

2.18 mm²
2.15 mm²
8.29 mm²
2.58 mm²
8.33 mm²
1.68 mm²
5.00 mm²
78 mm
15 mm
CardioVascular Research Foundation
UNIVERSITY OF ULSAN COLLEGE MEDICINE
ASAN Medical Center

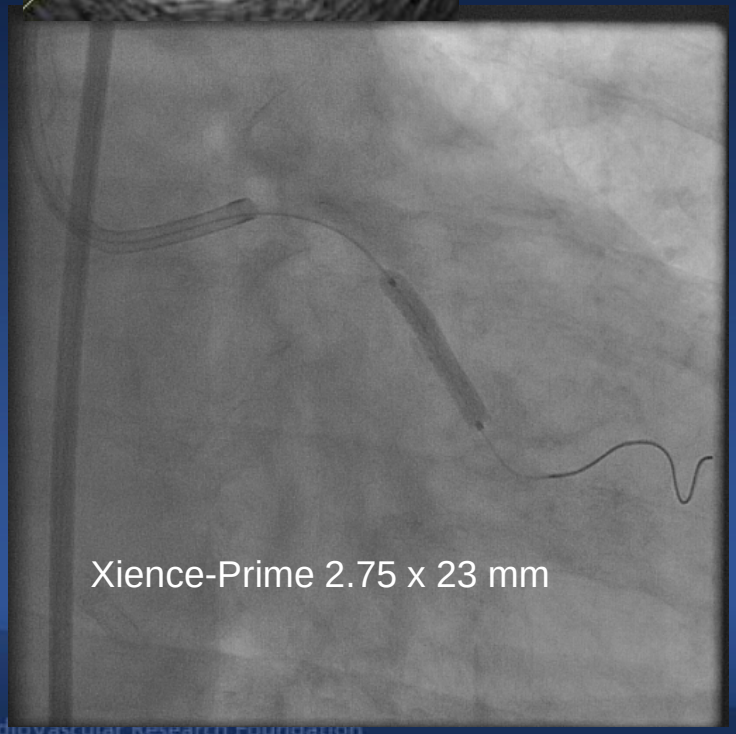
RCA Intervention

Pre-FFR 0.72 in dRCA

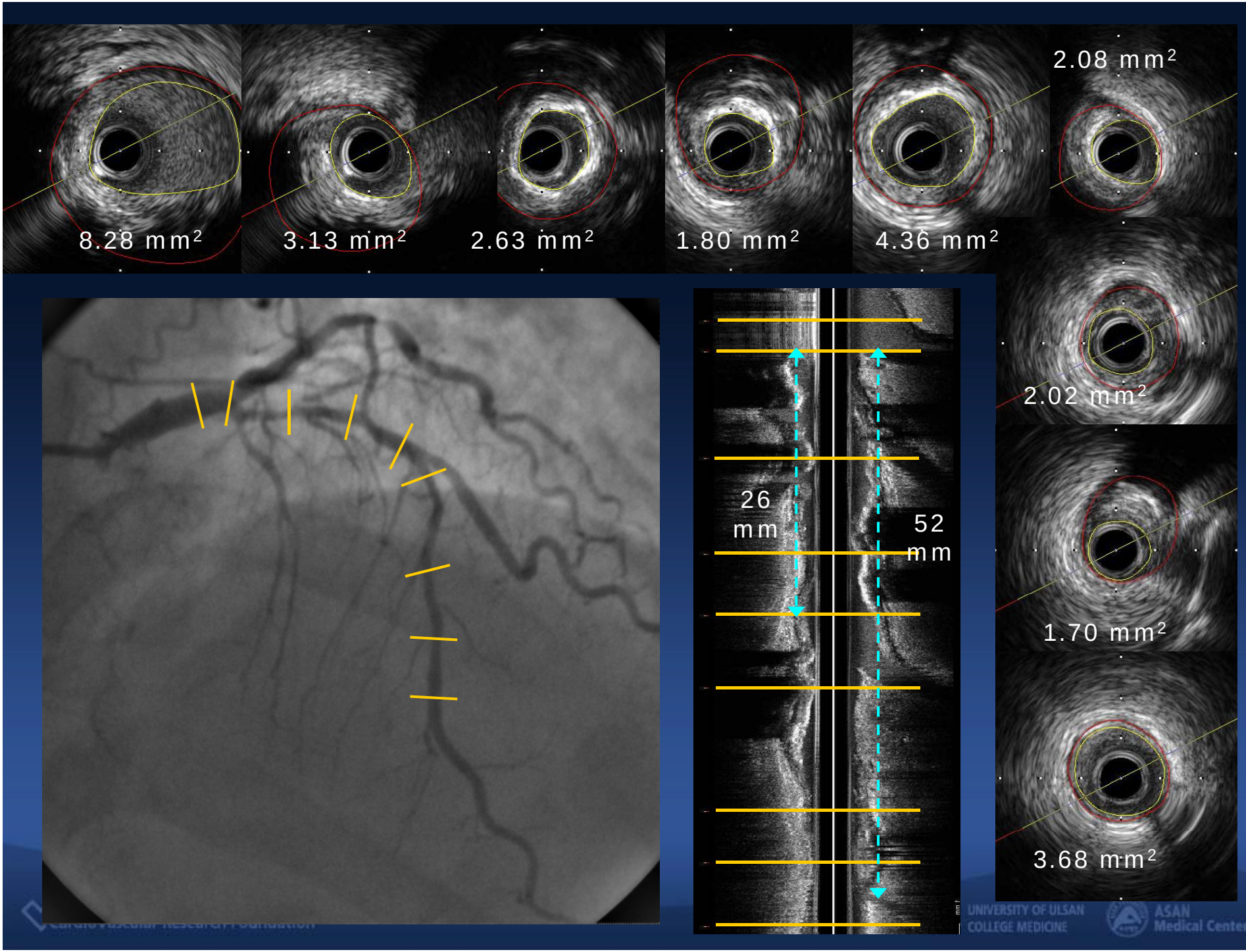


IVUS and LCX Stenting without FFR





Xience-Prime 2.75 x 23 mm


8.28 mm²
3.13 mm²
2.63 mm²
1.80 mm²
4.36 mm²
2.08 mm²
2.02 mm²
1.70 mm²
3.68 mm²
26 mm
52 mm
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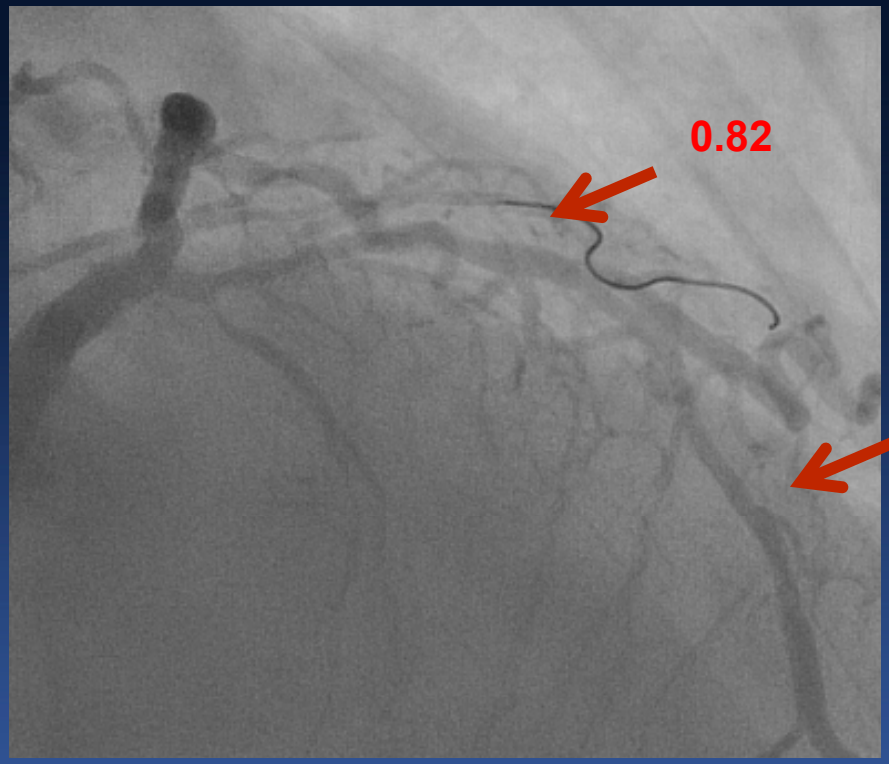
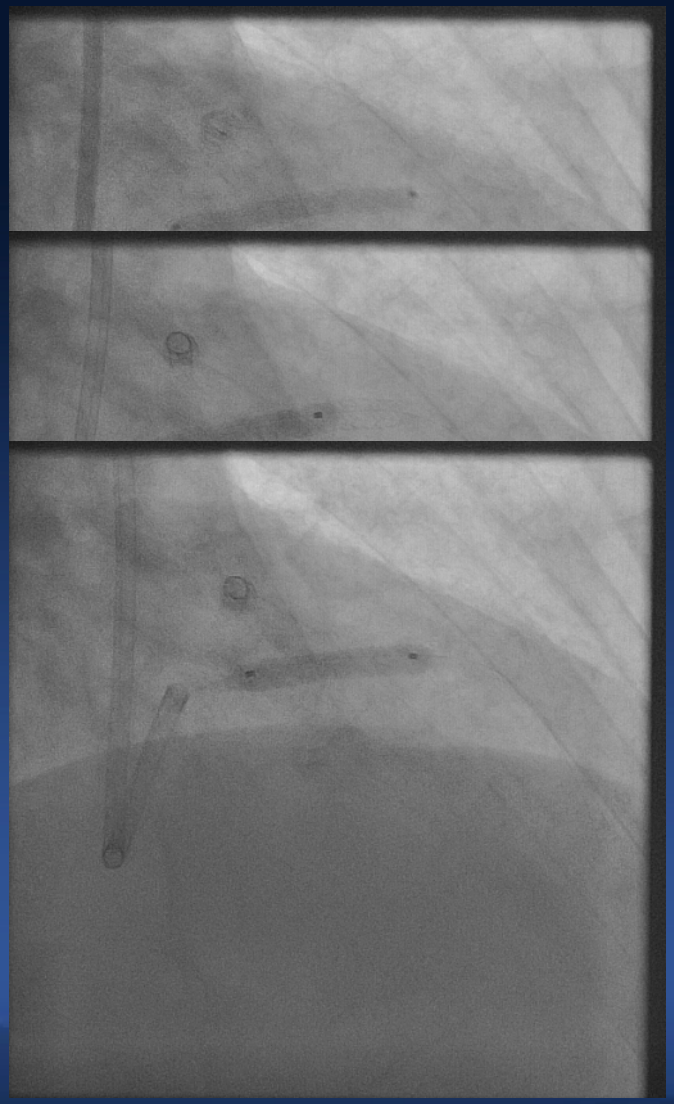
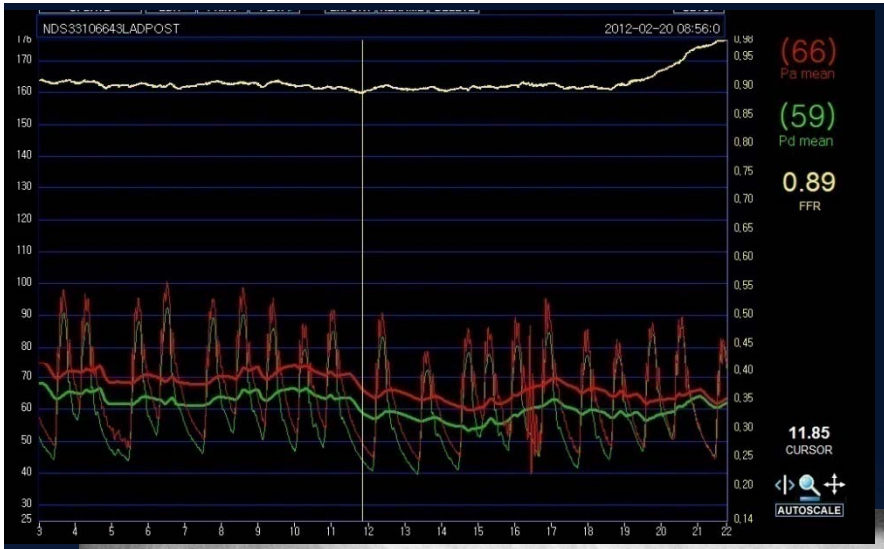
LAD Intervention with FFR



Stenting followed by NC



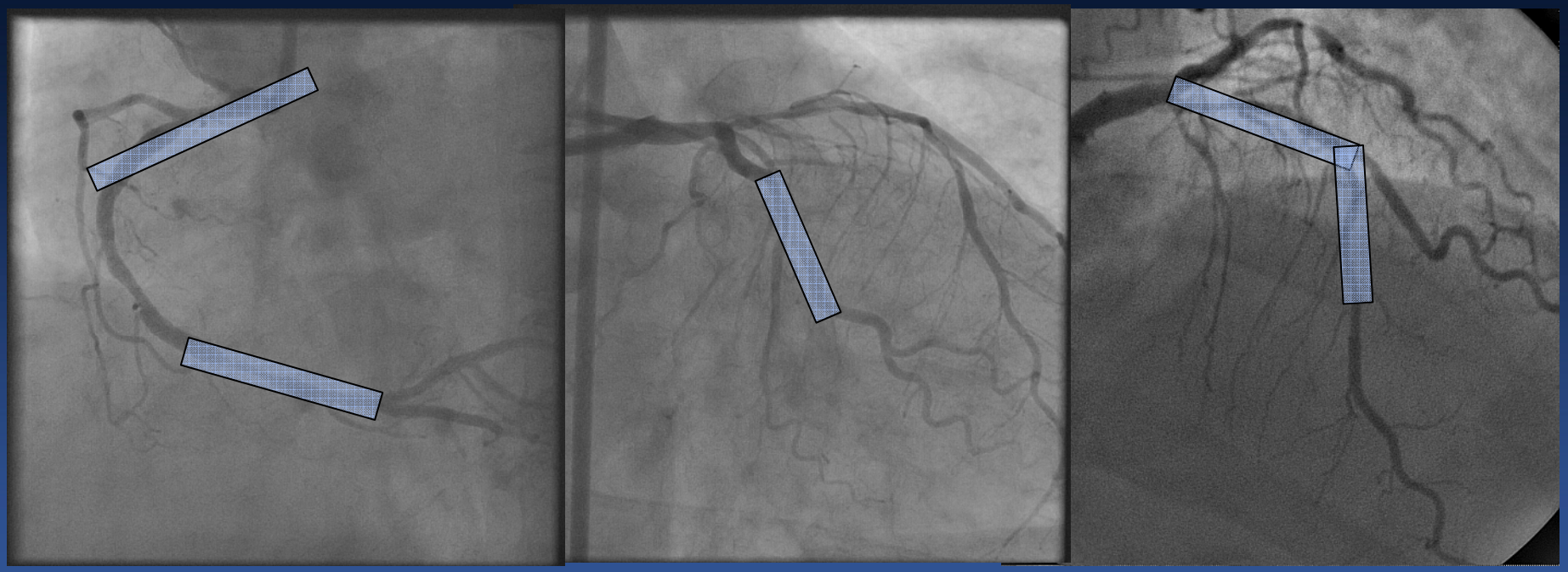

NDS33106643LADPOST
2012-02-20 08:56:0
(66)
Pa mean
(59)
Pd mean
0.89
FFR
11.85
CURSOR
AUTOSCALE

Post-FFR

Function-guided PCI

Reasonable Incomplete Revascularization

using 3 stents

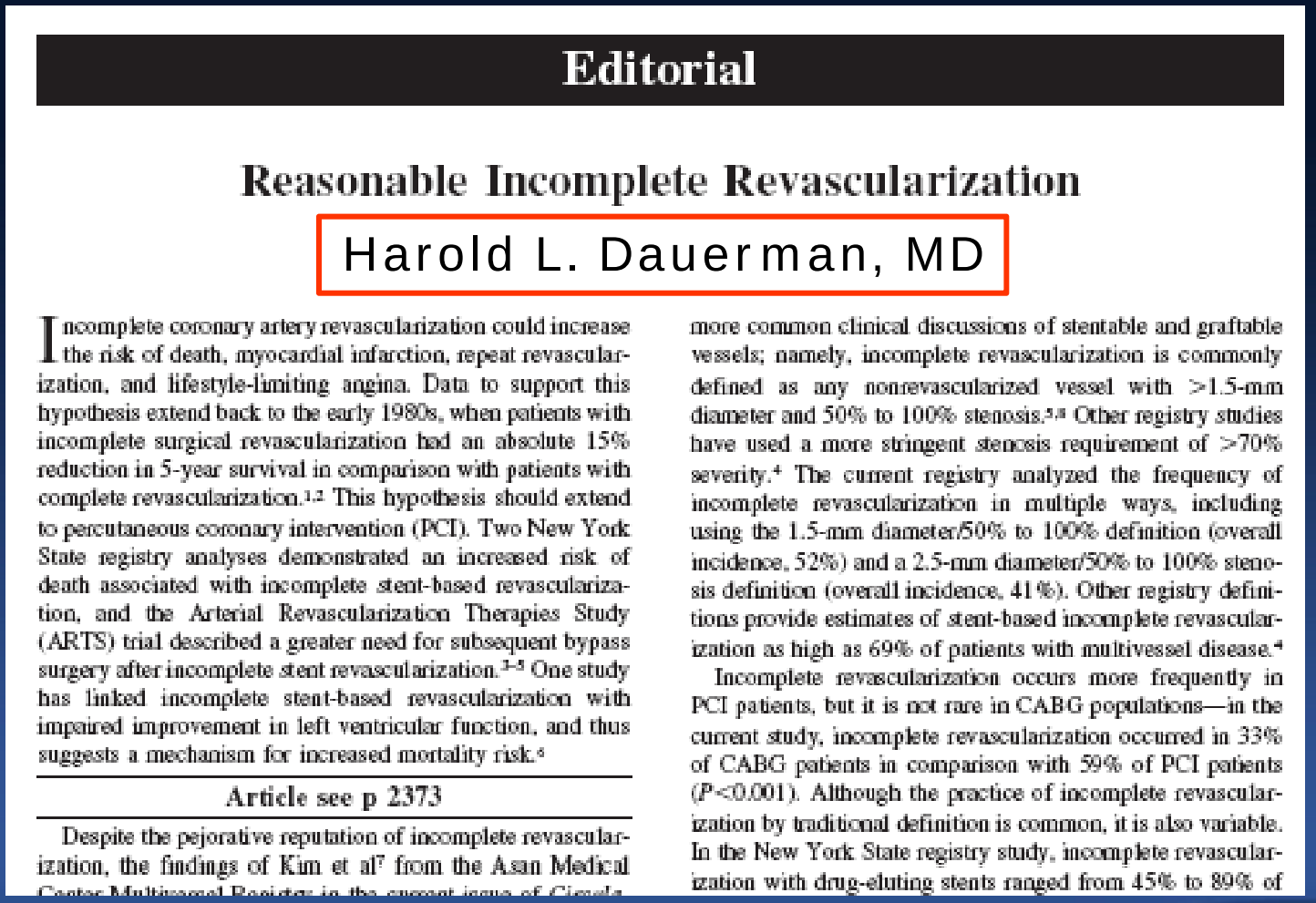


ESC 2011 Update
Indications of Revascularization

	Subset of CAD by anatomy	Class	Level
For prognosis	Left main >50% *	I	A
	Any proximal LAD >50% *	I	A
	2VD or 3VD with impaired LV function *	I	B
	Proven large area of ischemia (> 10%LV)	I	B
	Single remaining patent vessel >50% stenosis *	I	C
	1VD without proximal LAD and without>10% ischemia	III	A
For symptoms	Any stenosis>50% with limiting angina or angina equivalent, unresponsive to OMT	I	A
	Dyspnea/CHF and>10%LV ischemia/viability supplied by >50% stenotic artery	IIa	B
	No limiting symptoms with OMT	III	C

* With documented ischemia or FFR < 0.8

Reasonable Incomplete Revascularization



Editorial

Reasonable Incomplete Revascularization

Harold L. Dauerman, MD

Incomplete coronary artery revascularization could increase the risk of death, myocardial infarction, repeat revascularization, and lifestyle-limiting angina. Data to support this hypothesis extend back to the early 1980s, when patients with incomplete surgical revascularization had an absolute 15% reduction in 5-year survival in comparison with patients with complete revascularization.[1,2] This hypothesis should extend to percutaneous coronary intervention (PCI). Two New York State registry analyses demonstrated an increased risk of death associated with incomplete stent-based revascularization, and the Arterial Revascularization Therapies Study (ARTS) trial described a greater need for subsequent bypass surgery after incomplete stent revascularization.[3–5] One study has linked incomplete stent-based revascularization with impaired improvement in left ventricular function, and thus suggests a mechanism for increased mortality risk.[6]

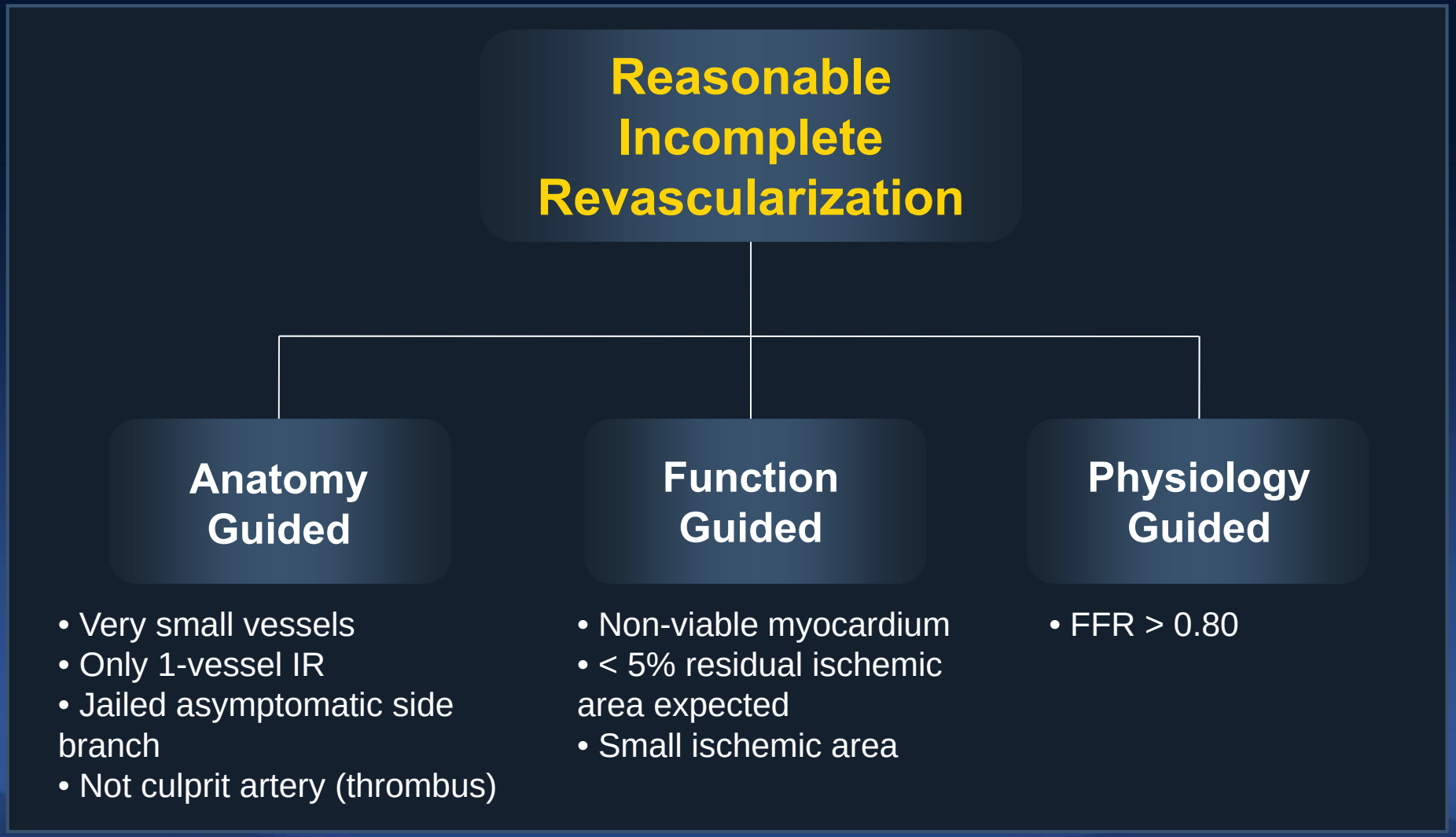
Article see p 2373

Despite the pejorative reputation of incomplete revascularization, the findings of Kim et al[7] from the Asan Medical Center Multivessel Registry in the current issue of *Circula-*

more common clinical discussions of stentable and graftable vessels; namely, incomplete revascularization is commonly defined as any nonrevascularized vessel with >1.5-mm diameter and 50% to 100% stenosis.[5,6] Other registry studies have used a more stringent stenosis requirement of >70% severity.[4] The current registry analyzed the frequency of incomplete revascularization in multiple ways, including using the 1.5-mm diameter/50% to 100% definition (overall incidence, 52%) and a 2.5-mm diameter/50% to 100% stenosis definition (overall incidence, 41%). Other registry definitions provide estimates of stent-based incomplete revascularization as high as 69% of patients with multivessel disease.[4]

Incomplete revascularization occurs more frequently in PCI patients, but it is not rare in CABG populations—in the current study, incomplete revascularization occurred in 33% of CABG patients in comparison with 59% of PCI patients ($P<0.001$). Although the practice of incomplete revascularization by traditional definition is common, it is also variable. In the New York State registry study, incomplete revascularization with drug-eluting stents ranged from 45% to 89% of

What is a reasonable incomplete revascularization ?



Dauerman HL. Circulation. 2011;123:2337

Impact of SPECT-based ischemia-guided revascularization

- To evaluate the prognostic impact of ischemia-guided (IG) revascularization using MPI in patients with MVD who underwent PCI with DES or CABG surgery in AMC.

YH Kim et al. J Am Coll Cardiol 2012 (in print)

Patients and Procedures

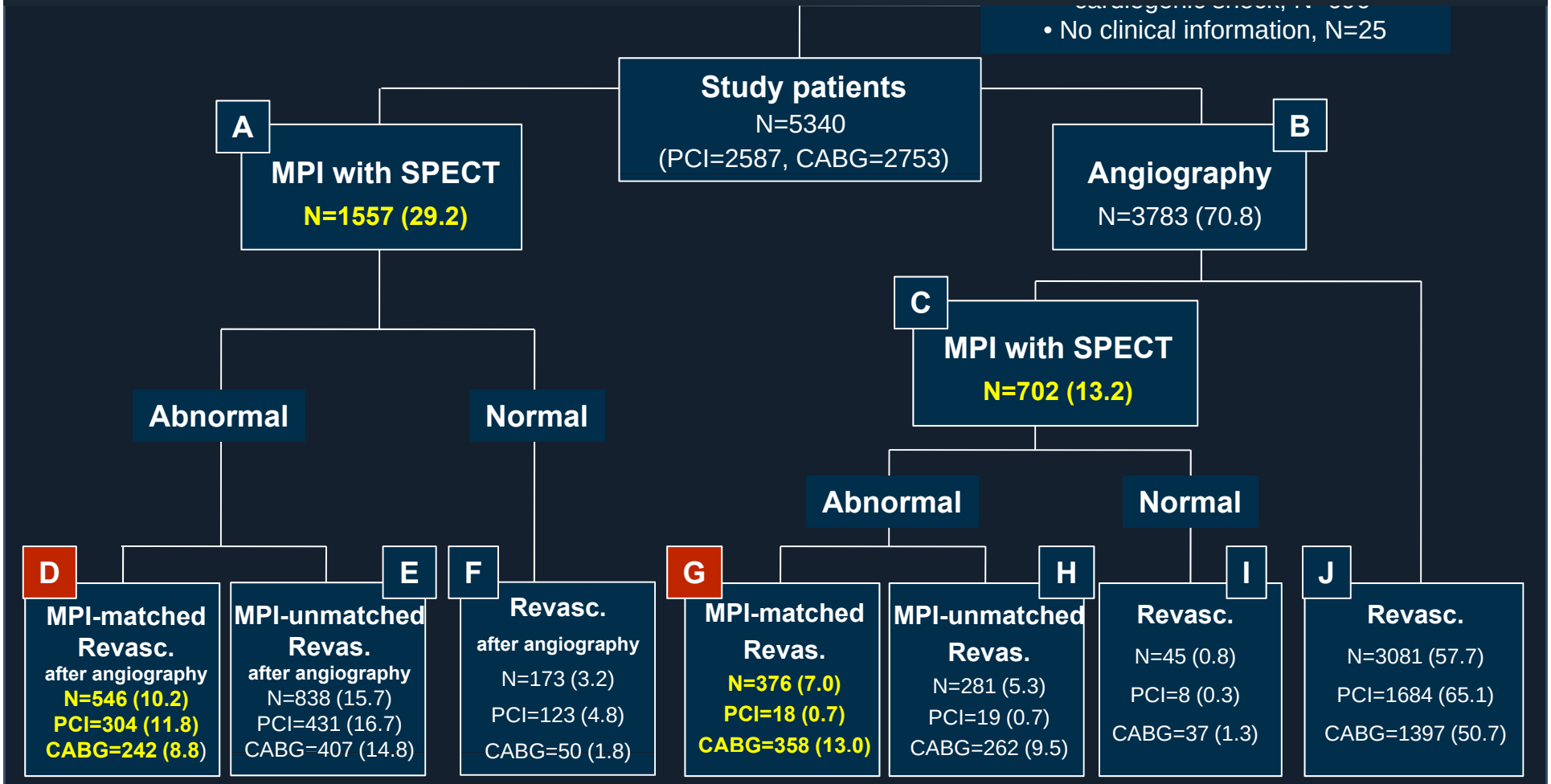
- The study population was a part of the **Asan Multivessel Registry** and included consecutive patients with MVD who underwent PCI with DES or CABG.
- **TI-201 SPECT** was the default stress MPI during the study period (2003 to 2006).
- FFR was rarely performed in the study period.

Definition of IG according to MPI

- **Ischemia-guided (IG) revascularization**
  - Revascularization a **LAD** and/or **non-LAD artery** matched with the perfusion abnormalities of MPI during the index hospitalization or within 30 days after the index procedure.

- **Non-IG revascularization**
  - Revascularization for non-ischemic vessels
  - Non-revascularization for ischemic vessels
  - Angiography-guided revascularization without MPI

922 (17.3%) comprising 322 (12.4%) in the PCI and 600 (21.8%) in the CABG (*P*<.001) patients underwent SPECT-guided IG revascularization.



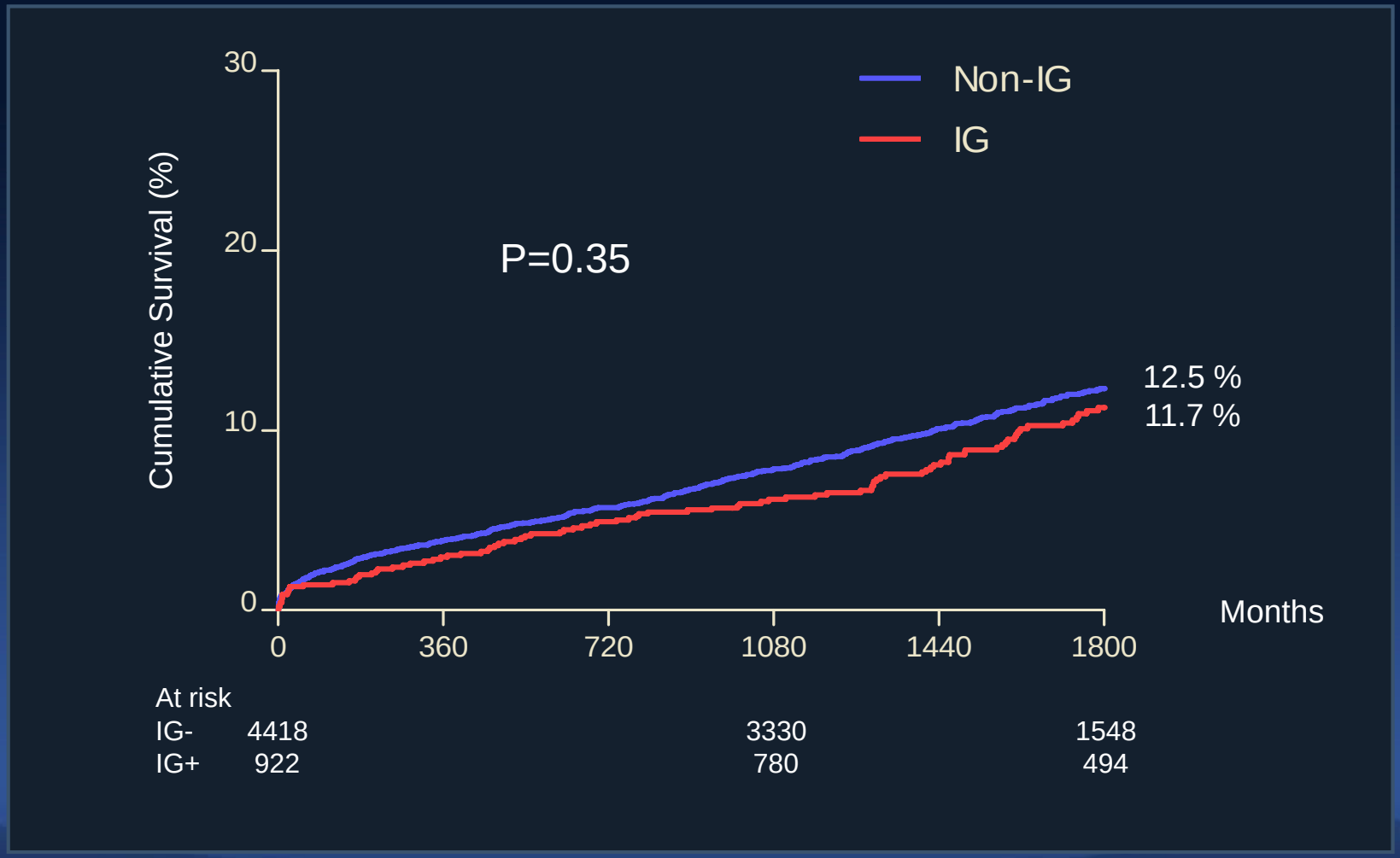
Angiographic Characteristics

	PCI			CABG		
	IG	Non-IG	*P*	IG	Non-IG	*P*
	N=310	N=1713		N=268	N=1061	
SYNTAX score, median	15.5	17.0	0.30	24.5	23.0	0.016
Angiographic stenosis						
LAD artery	260 (83.9)	1555 (90.8)	<0.001	214 (79.9)	854 (80.5)	0.81
Left circumflex artery	202 (65.2)	1106 (64.6)	0.84	160 (59.7)	679 (64.0)	0.19
Right coronary artery	229 (73.9)	1252 (73.1)	0.78	190 (70.9)	746 (70.3)	0.85
Left main	34 (11.0)	261 (15.2)	0.050	95 (35.4)	327 (30.8)	0.15
Three-vessel disease	127 (41.0)	714 (41.7)	0.82	147 (54.9)	604 (56.9)	0.54
Any total occlusion	61 (19.7)	247 (14.4)	0.018	98 (36.6)	283 (26.7)	0.001

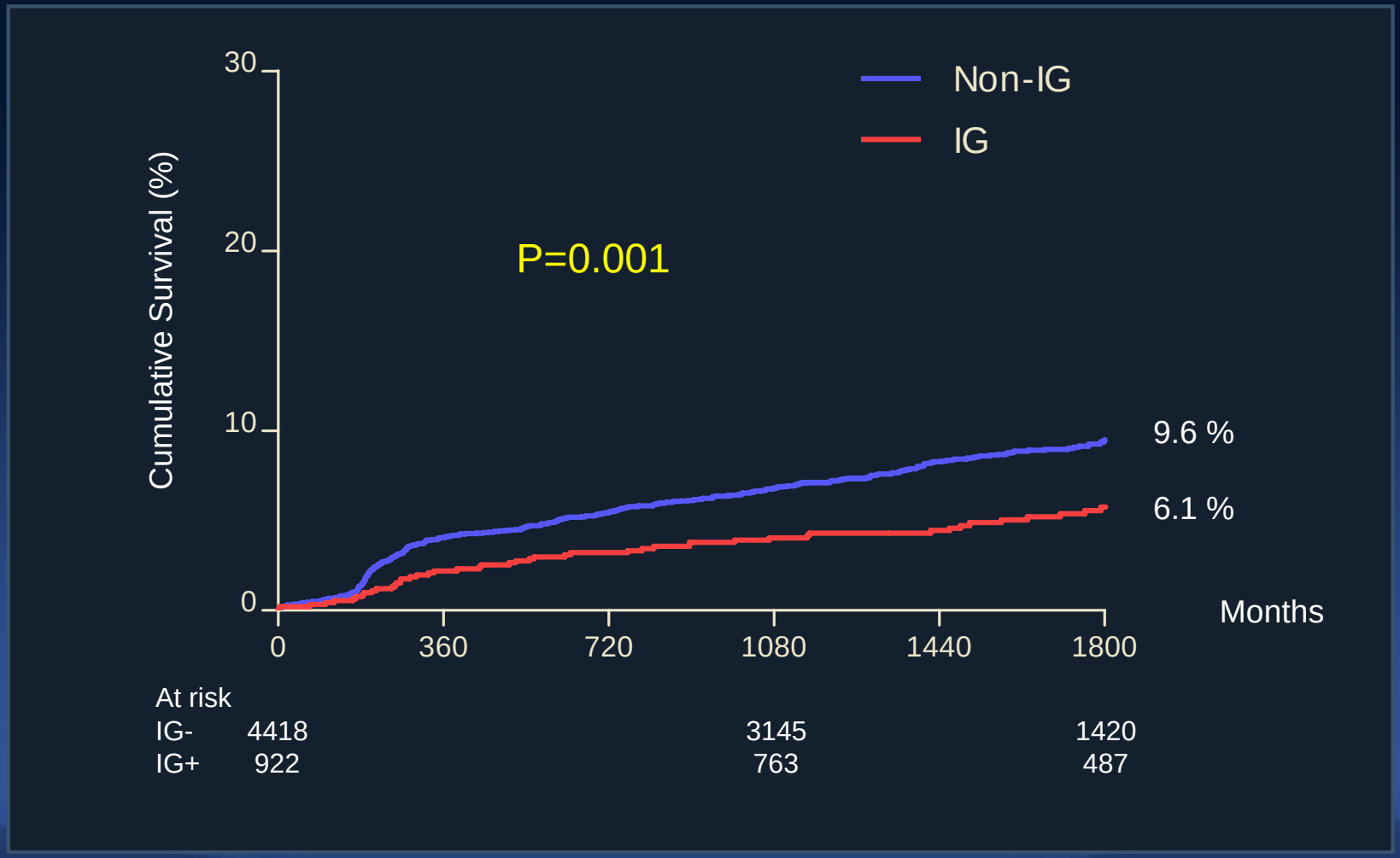
Procedures

	PCI			CABG		
	IG	Non-IG	*P*	IG	Non-IG	*P*
	N=322	N=2265		N=600	N=2153	
Treadmill test	113 (35.1)	431 (19.0)	<0.001	99 (16.5)	251 (11.7)	0.002
Treated vessel						
LAD or left main artery	205 (63.7)	1768 (78.1)	<0.001	589 (98.2)	2091 (97.1)	0.16
Left circumflex artery	113 (35.1)	940 (41.5)	0.029	477 (79.5)	1680 (78.0)	0.44
Right coronary artery	138 (42.9)	1172 (51.7)	0.003	439 (73.2)	1427 (66.3)	0.001
Conduits, median	–	–	–	3.0 (3.0, 4.0)	3.0 (2.0, 4.0)	<0.001
Arterial conduit, median	–	–	–	3.0 (2.0, 3.0)	2.0 (1.0, 3.0)	<0.001
Internal thoracic artery	–	–	–	510 (85.0)	1867 (86.7)	0.28
Off-pump surgery	–	–	–	370 (61.7)	1243 (57.7)	0.084
Total stents, median	2.0 (1.0, 3.0)	2.0 (2.0, 3.0)	<0.001	–	–	–

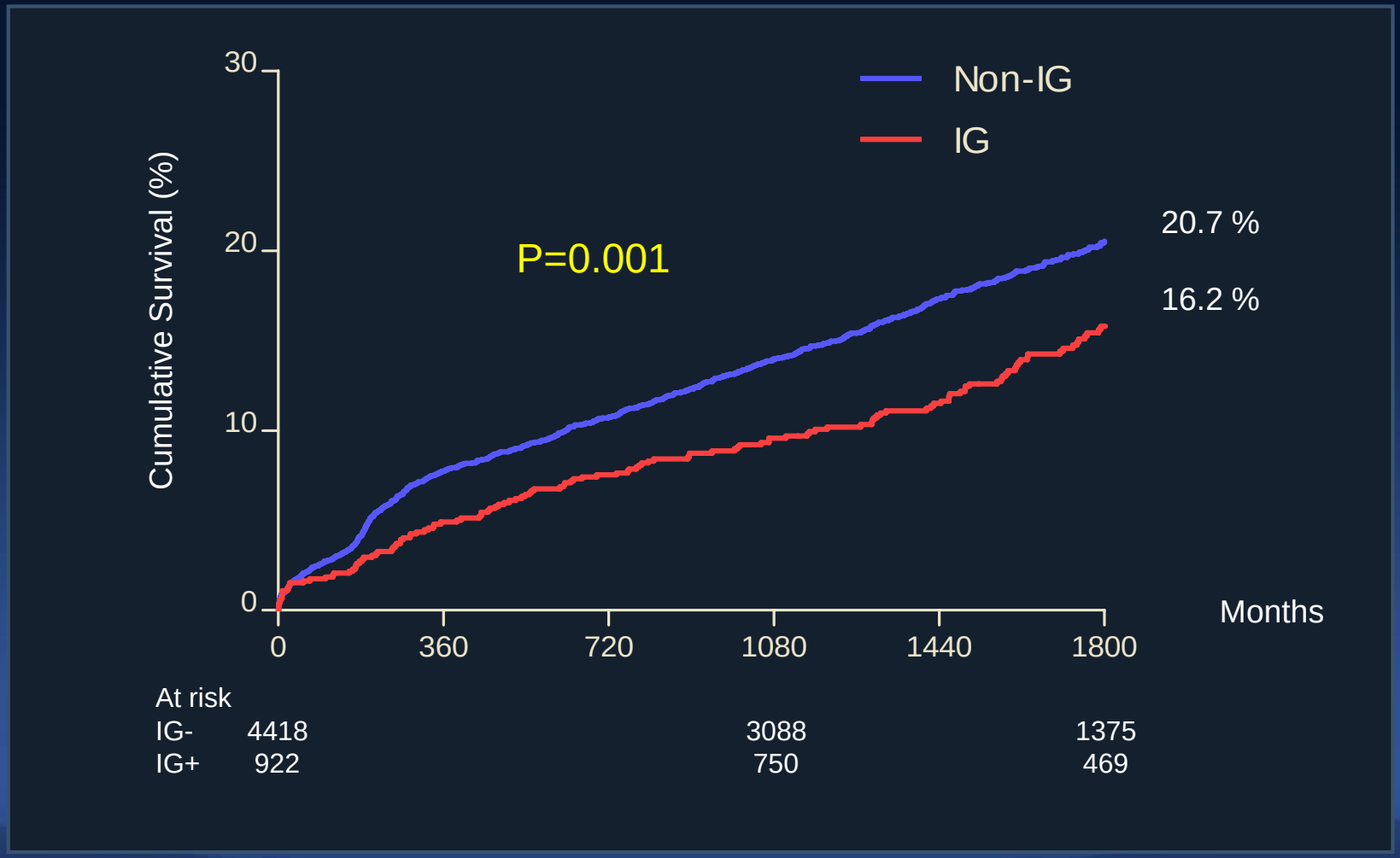
All Patients
Death, MI, or Stroke for 5 Years



All Patients
Repeat Revascularization for 5 Years

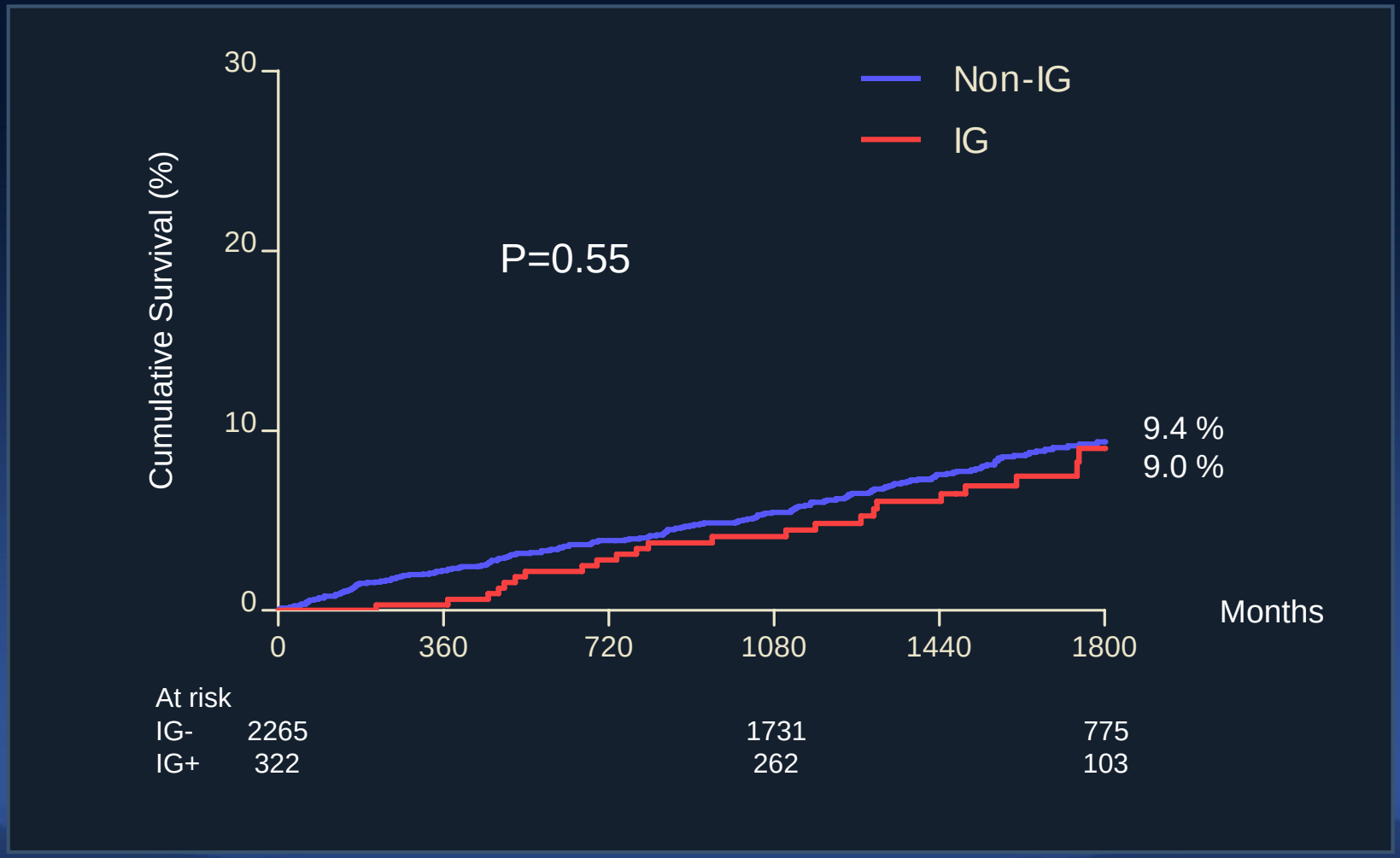


All Patients
MACCE for 5 Years



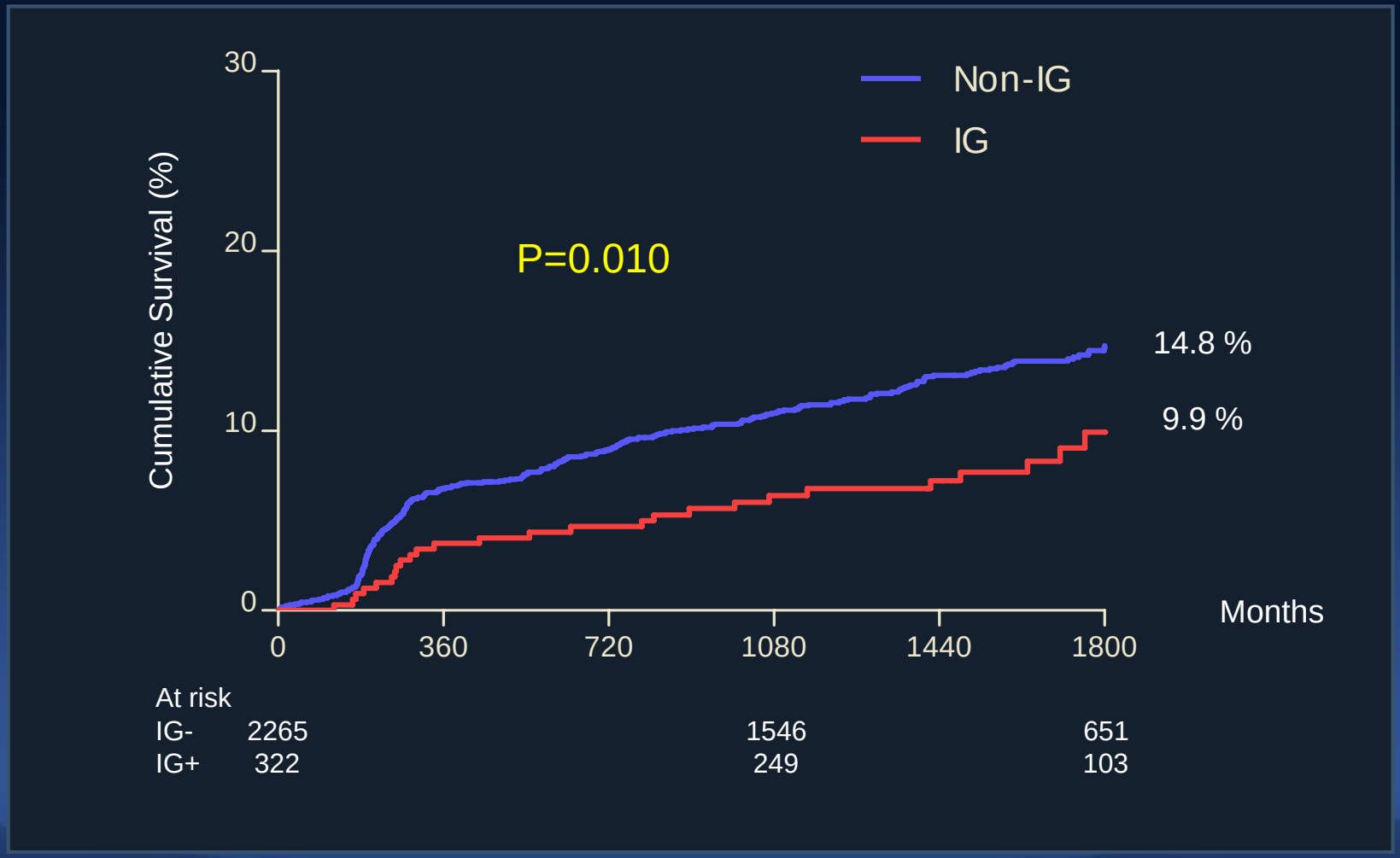
PCI Patients

Death, MI, or Stroke for 5 Years

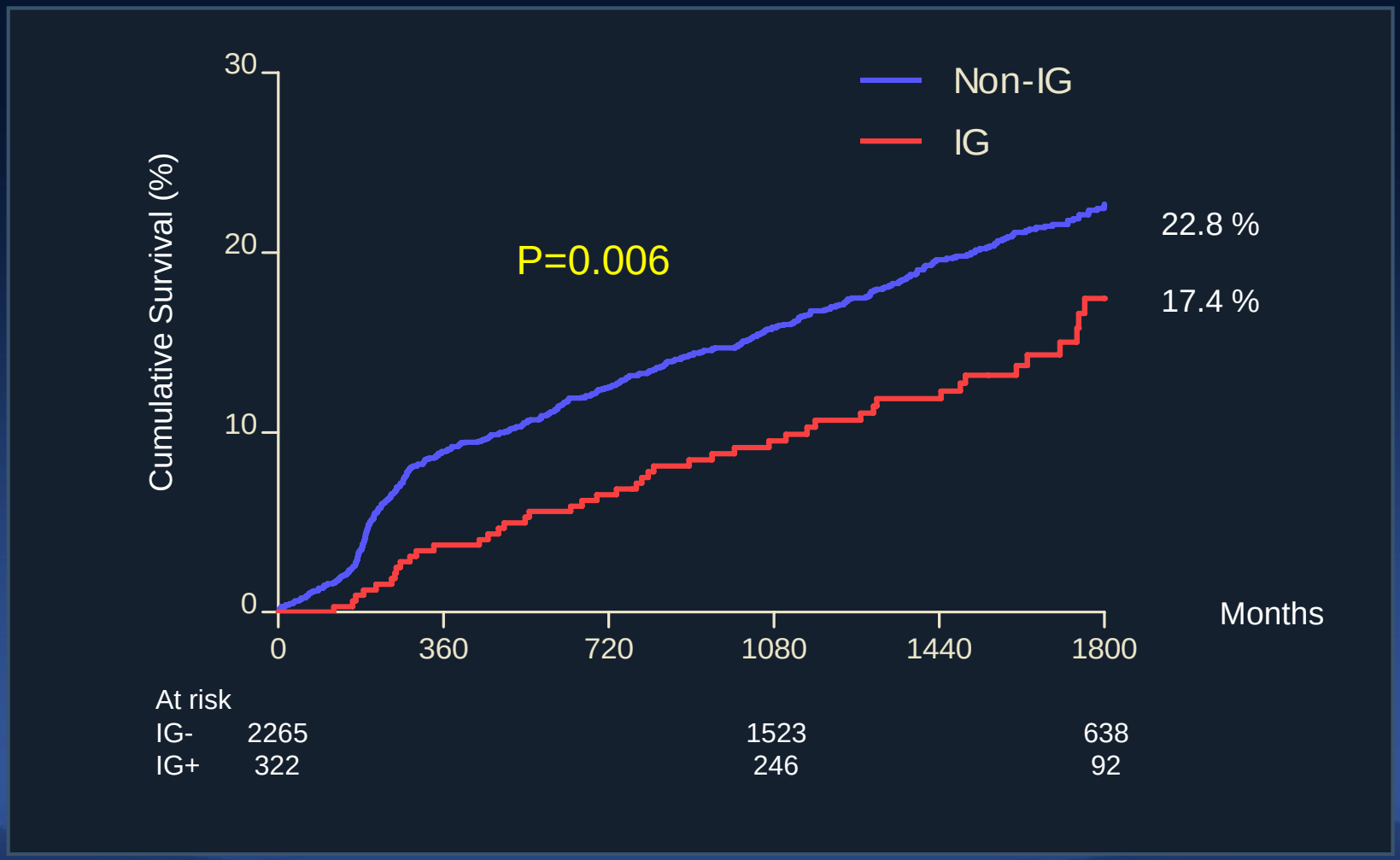


PCI Patients

Repeat Revascularization for 5 Years

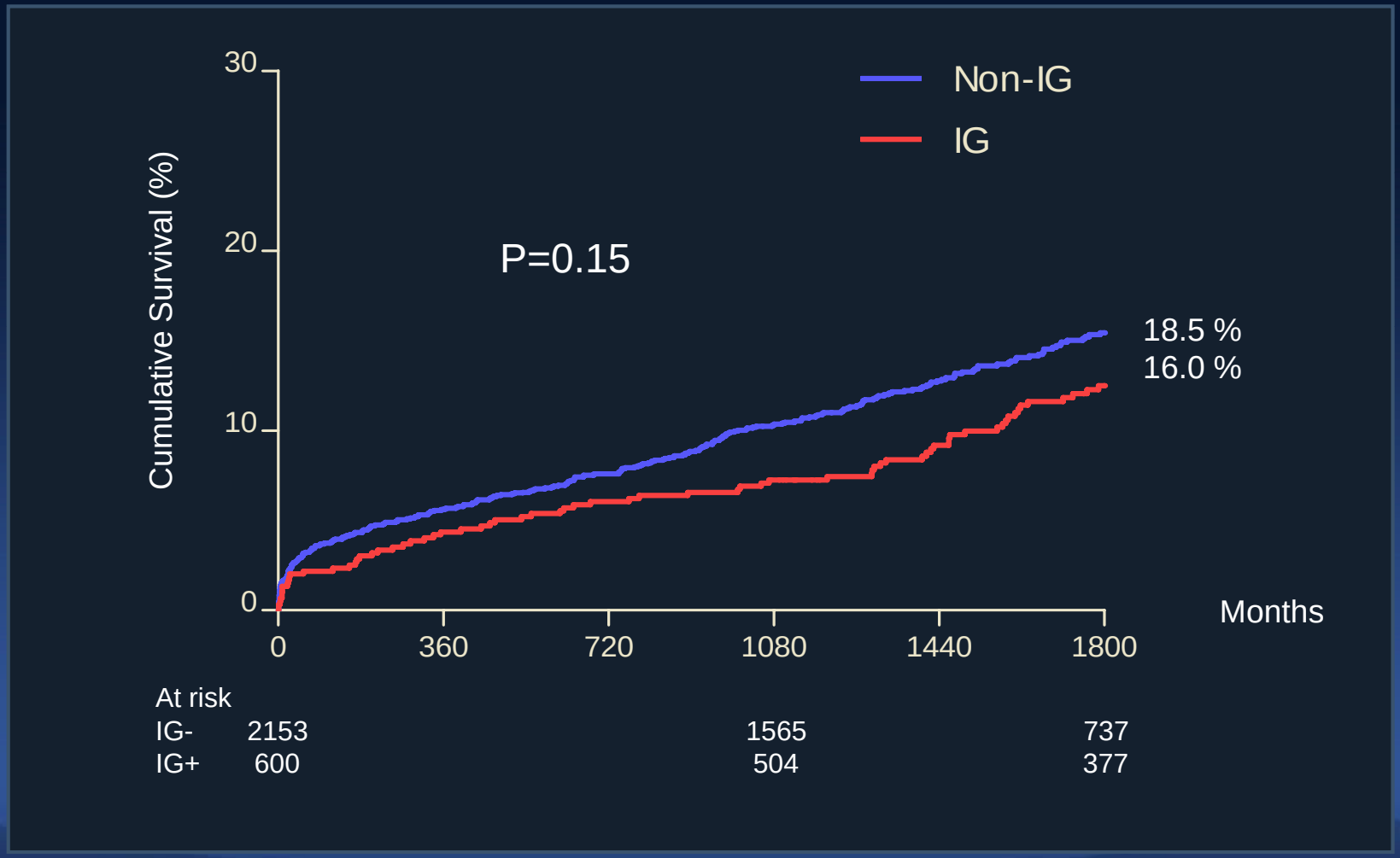


PCI Patients
MACCE for 5 Years



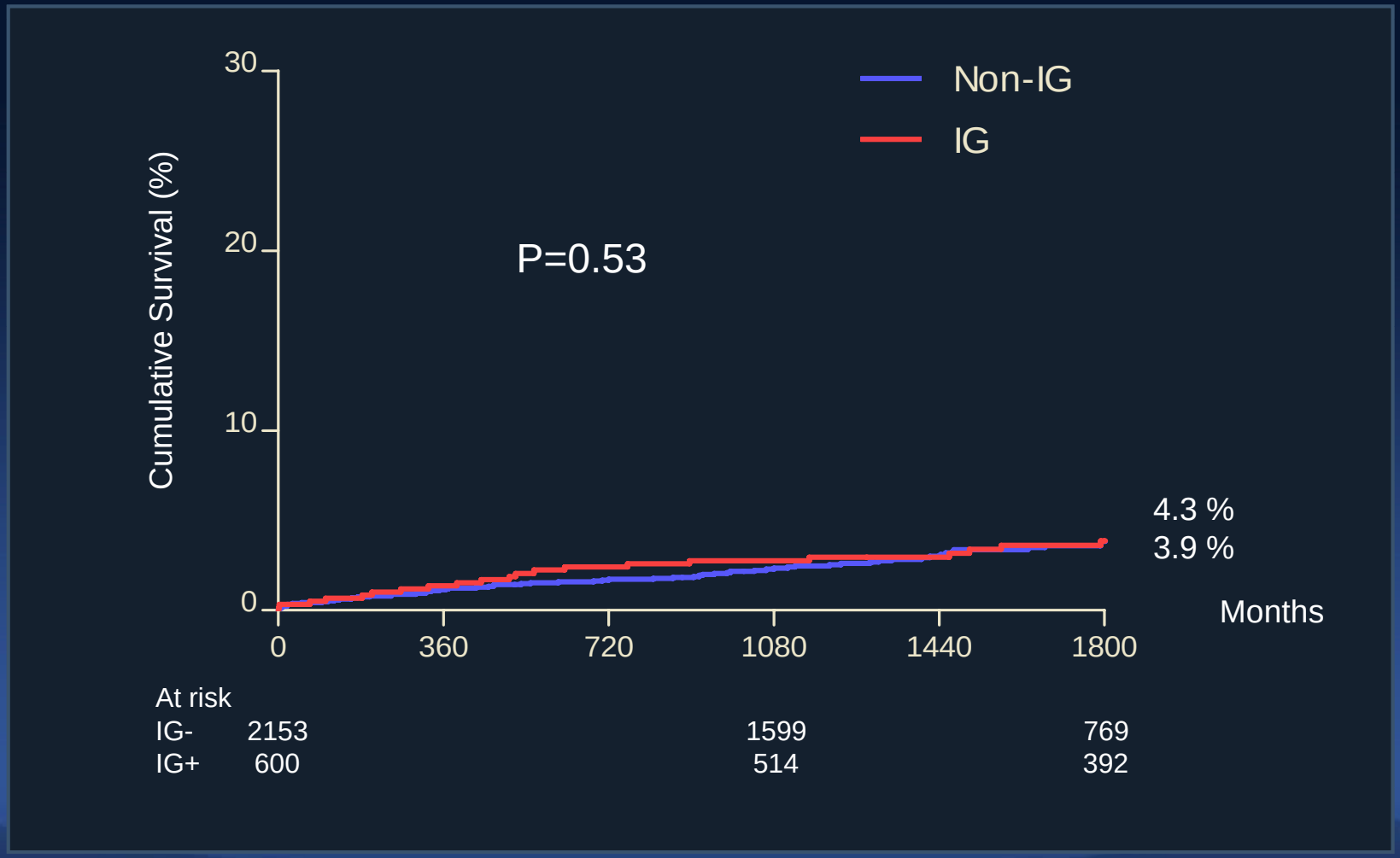
CABG Patients

Death, MI, or Stroke for 5 Years

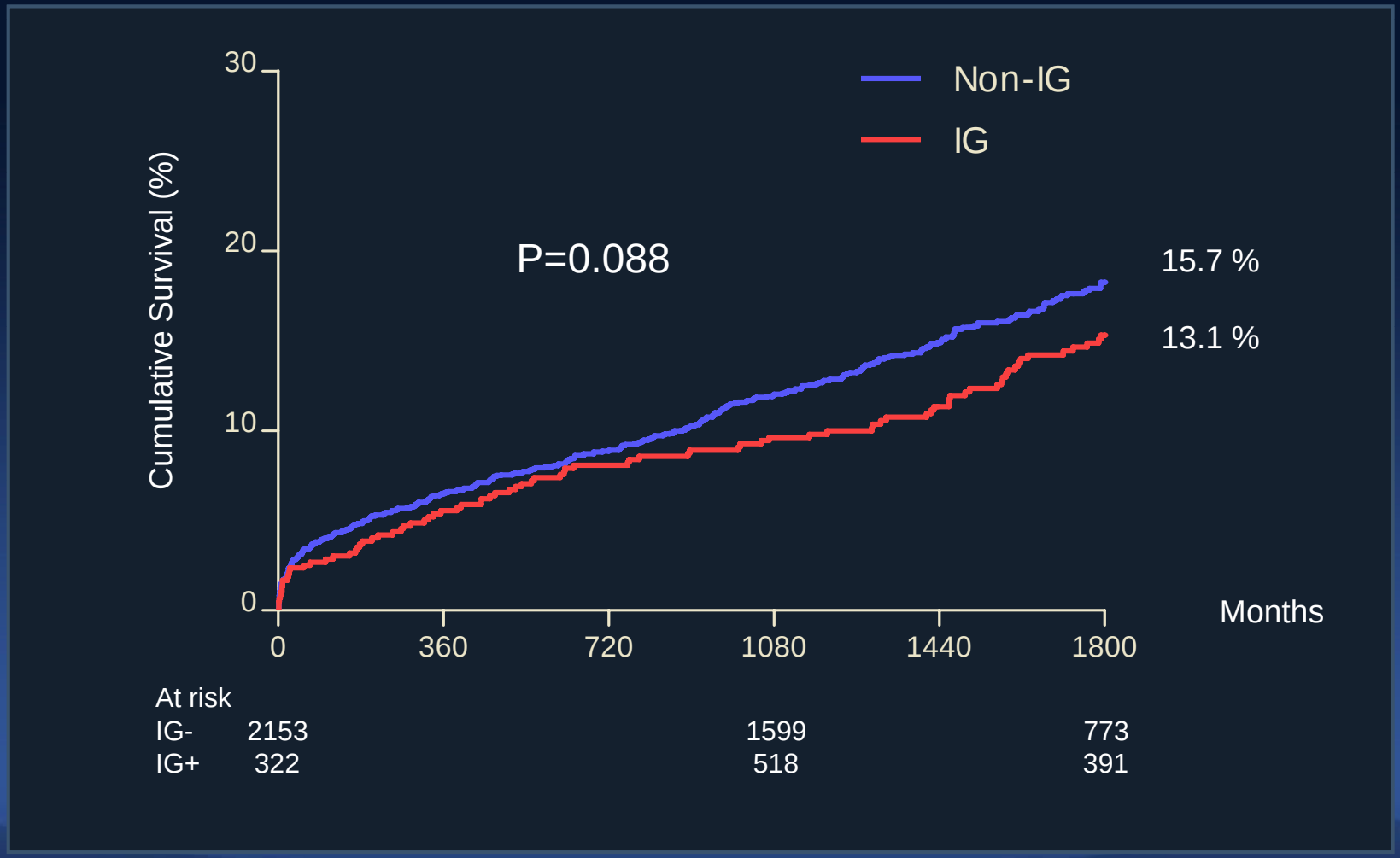


CABG Patients

Repeat Revascularization for 5 Years



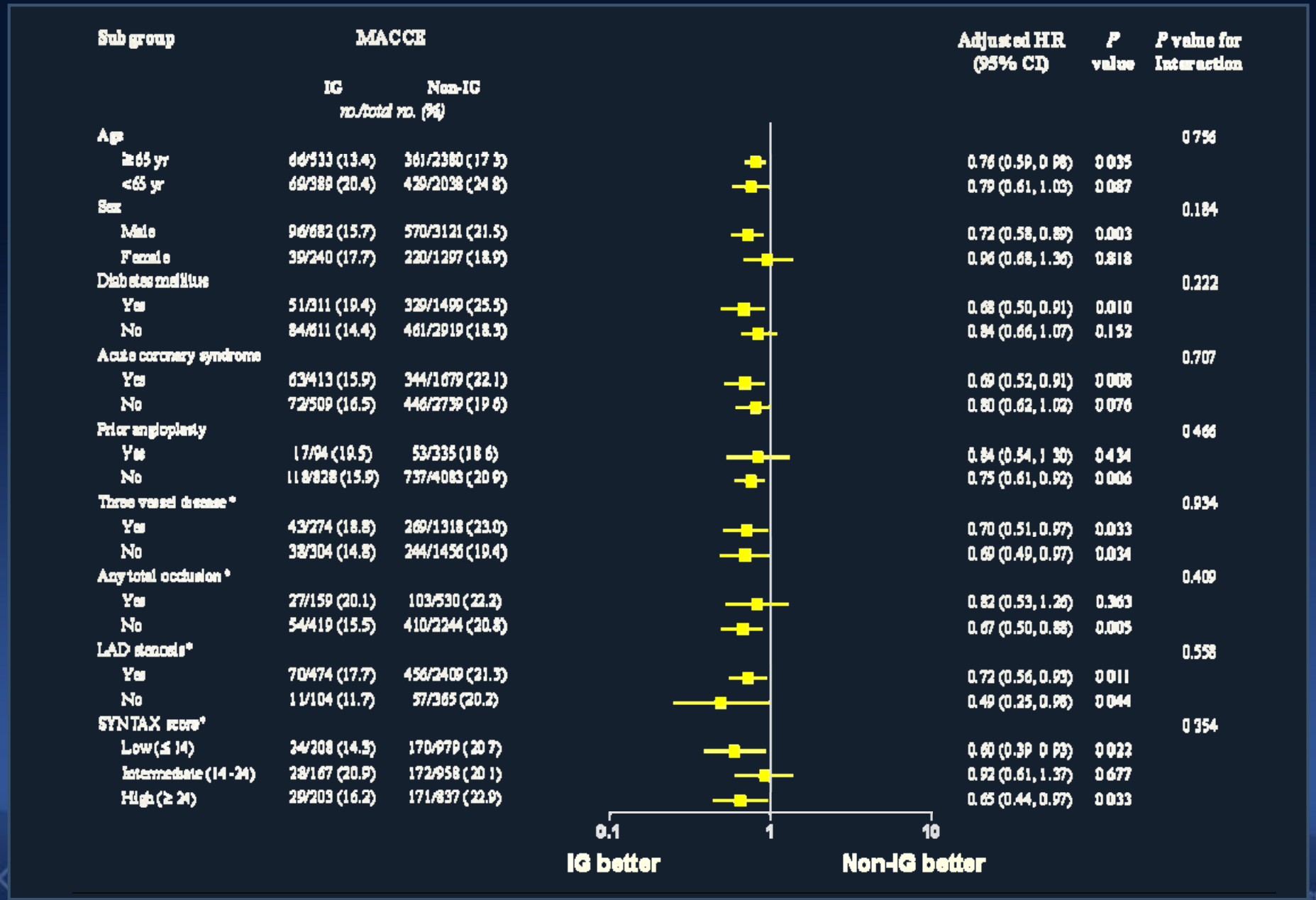
CABG Patients
MACCE for 5 Years



Adjusted Hazards using Inverse-probability-of-treatment weighting

		HR	95% CI		*P*	Interaction *P*
			Lower	Upper		
Death, MI, stroke	All	0.84	0.66	1.06	0.13	
	PCI	0.83	0.53	1.29	0.41	0.96
	CABG	0.82	0.61	1.10	0.18	
Repeat revascularization	All	0.66	0.49	0.90	0.009	
	PCI	0.53	0.35	0.80	0.003	0.044
	CABG	1.16	0.70	1.94	0.57	
MACCE	All	0.73	0.60	0.88	0.001	
	PCI	0.59	0.43	0.81	0.001	0.18
	CABG	0.87	0.67	1.14	0.32	

5-Year MACCE in Subgroups



Subgroup	MACCE		Adjusted HR (95% CI)	*P* value	*P* value for Interaction
	IG	Non-IG			
	no./total no. (%)				
Age					0.756
≥65 yr	66/533 (13.4)	361/2380 (17.3)	0.76 (0.59, 0.98)	0.035	
<65 yr	69/389 (20.4)	429/2038 (24.8)	0.79 (0.61, 1.03)	0.087	
Sex					0.184
Male	96/682 (15.7)	570/3121 (21.5)	0.72 (0.58, 0.89)	0.003	
Female	39/240 (17.7)	220/1297 (18.9)	0.96 (0.68, 1.36)	0.818	
Diabetes mellitus					0.222
Yes	51/311 (19.4)	329/1499 (25.5)	0.68 (0.50, 0.91)	0.010	
No	84/611 (14.4)	461/2919 (18.3)	0.84 (0.66, 1.07)	0.152	
Acute coronary syndrome					0.707
Yes	63/413 (15.9)	344/1679 (22.1)	0.69 (0.52, 0.91)	0.008	
No	72/509 (16.5)	446/2739 (19.6)	0.80 (0.62, 1.02)	0.076	
Prior angioplasty					0.466
Yes	17/94 (19.5)	53/335 (18.6)	0.84 (0.54, 1.30)	0.434	
No	118/828 (15.9)	737/4083 (20.9)	0.75 (0.61, 0.92)	0.006	
Three vessel disease*					0.934
Yes	43/274 (18.8)	269/1318 (23.0)	0.70 (0.51, 0.97)	0.033	
No	38/304 (14.8)	244/1456 (19.4)	0.69 (0.49, 0.97)	0.034	
Any total occlusion*					0.409
Yes	27/159 (20.1)	103/530 (22.2)	0.82 (0.53, 1.26)	0.363	
No	54/419 (15.5)	410/2244 (20.8)	0.67 (0.50, 0.88)	0.005	
LAD stenosis*					0.558
Yes	70/474 (17.7)	456/2409 (21.3)	0.72 (0.56, 0.93)	0.011	
No	11/104 (11.7)	57/365 (20.2)	0.49 (0.25, 0.96)	0.044	
SYNTAX score*					0.354
Low (≤ 14)	34/208 (14.5)	170/979 (20.7)	0.60 (0.39, 0.93)	0.022	
Intermediate (14-24)	28/167 (20.9)	172/958 (20.1)	0.92 (0.61, 1.37)	0.677	
High (≥ 24)	29/203 (16.2)	171/837 (22.9)	0.65 (0.44, 0.97)	0.033	

Ischemia-Guided Revascularization

- IG revascularization may extend the indication of PCI compared with angiography-guided revascularization.
- It may be a more cost-effective way of PCI with fewer devices (DESs).
- It may improve long-term clinical outcomes of PCI.
- Smart noninvasive imaging modalities, which adequately detect ischemic patients, vessels and lesions to improve the diagnostic performance of CAD and to delineate ischemic segments for IG revascularization.

Ischemia-guided PCI using New Perfusion Imaging of CT, MR or others to improve spatial resolution than SPECT.