Impact of Functional Angioplasty on Clinical Outcomes of PCI

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IVUS guided vs. CAG guided PCI Meta-analysis

A total of 23,392 patients
in 2 randomized trial and 12 observational studies

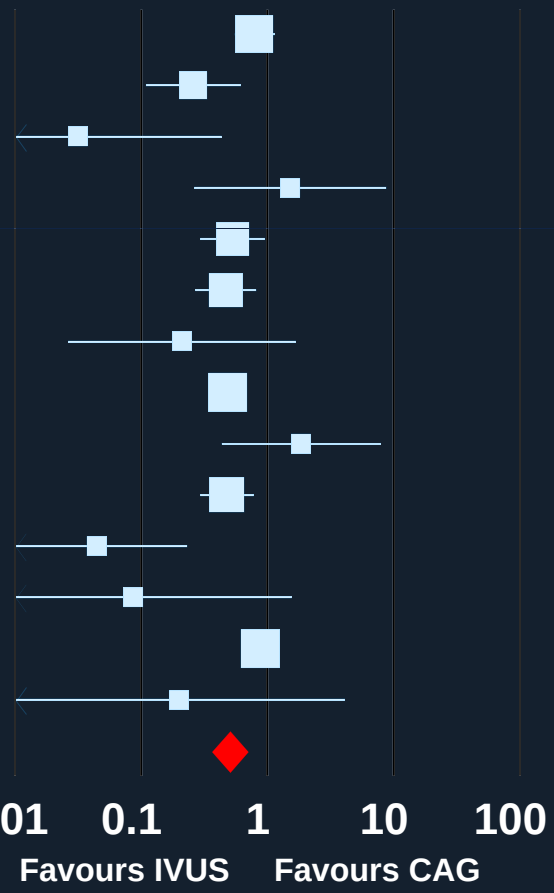
Park SJ, Ahn JM, unpublished data

Death from any causes

Study name	Time point	OR	LL	UL	Z-Value	P
Roy	2008	0.79	0.54	1.16	-1.20	0.23
MAIN-COMPARE	2009	0.26	0.11	0.63	-2.98	0.00
Kim	2010	0.03	0.00	0.44	-2.57	0.01
HOME DES IVUS	2010	1.52	0.26	8.87	0.46	0.64
MATRIX	2011	0.53	0.29	0.97	-2.07	0.04
COBIS	2011	0.47	0.26	0.83	-2.62	0.01
Youn	2011	0.21	0.03	1.70	-1.46	0.14
Hur	2012	0.49	0.36	0.66	-4.60	0.00
EXCELLENT	2012	1.84	0.42	7.99	0.82	0.41
Ahn	2012	0.48	0.29	0.79	-2.88	0.00
Patel	2012	0.04	0.01	0.24	-3.66	0.00
Chen	2012	0.09	0.00	1.58	-1.65	0.10
ADAPT-DES	2012	0.88	0.64	1.20	-0.82	0.41
AVIO	2013	0.20	0.01	4.17	-1.04	0.30
Random pooled estimate		**0.50**	**0.36**	**0.69**	**-4.10**	**<0.001**

I^2=63

Odds ratio and 95% CI



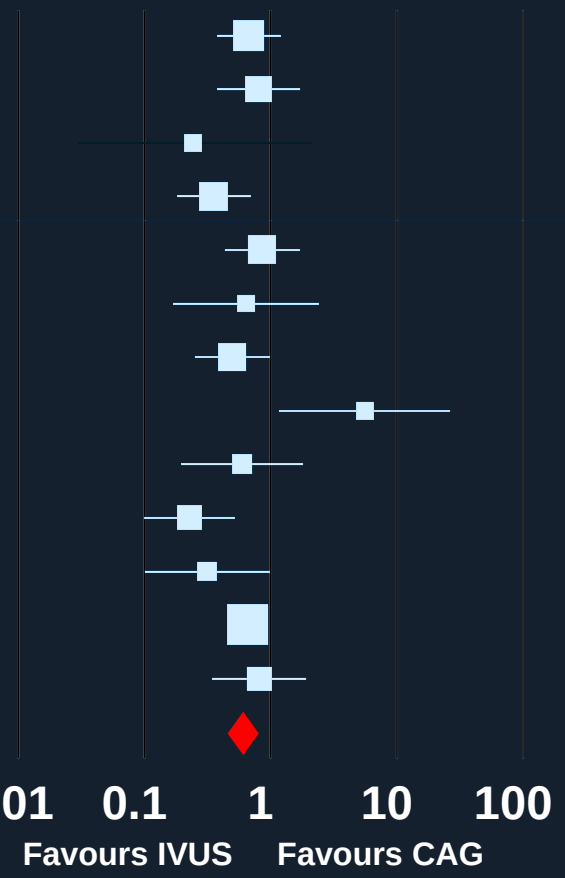
Park SJ, Ahn JM, unpublished data

Myocardial infarction

Study name	Time point	OR	LL	UL	Z-Value	P
Roy	2008	0.67	0.37	1.22	-1.31	0.19
MAIN-COMPARE	2009	0.81	0.37	1.75	-0.54	0.59
HOME DES IVUS	2010	0.24	0.03	2.09	-1.29	0.20
MATRIX	2011	0.35	0.18	0.71	-2.96	0.00
COBIS	2011	0.86	0.43	1.72	-0.43	0.66
Youn	2011	0.64	0.17	2.46	-0.65	0.52
Hur	2012	0.50	0.25	1.01	-1.95	0.05
EXCELLENT	2012	5.60	1.16	26.95	2.15	0.03
Ahn	2012	0.60	0.19	1.85	-0.89	0.37
Patel	2012	0.23	0.10	0.53	-3.44	0.00
Chen	2012	0.31	0.10	1.00	-1.97	0.05
ADAPT-DES	2012	0.66	0.51	0.86	-3.11	0.00
AVIO	2013	0.81	0.34	1.94	-0.47	0.64
Random pooled estimate		**0.59**	**0.45**	**0.79**	**-3.63**	**<0.001**

I^2=40

Odds ratio and 95% CI



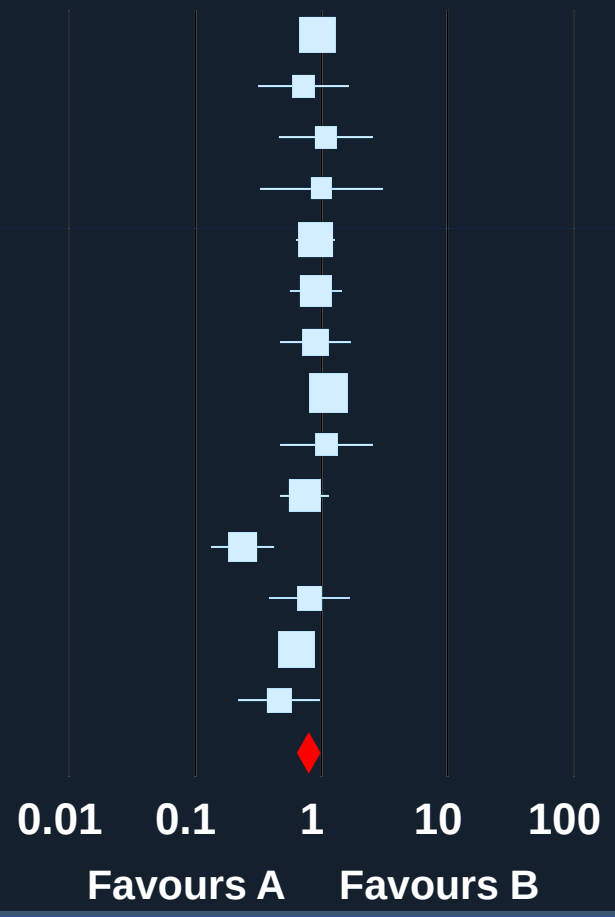
Park SJ, Ahn JM, unpublished data

Target vessel revascularization

Study name	Time point	OR	LL	UL	Z-Value	P
Roy	2008	0.94	0.68	1.31	-0.37	0.71
MAIN-COMPARE	2009	0.72	0.31	1.67	-0.77	0.44
Kim	2010	1.08	0.45	2.60	0.18	0.86
HOME DES IVUS	2010	1.00	0.32	3.12	0.00	1.00
MATRIX	2011	0.90	0.62	1.30	-0.57	0.57
COBIS	2011	0.90	0.55	1.47	-0.43	0.67
Youn	2011	0.90	0.46	1.75	-0.32	0.75
Hur	2012	1.13	0.89	1.44	1.04	0.30
EXCELLENT	2012	1.09	0.46	2.58	0.20	0.84
Ahn	2012	0.74	0.46	1.16	-1.31	0.19
Patel	2012	0.24	0.13	0.43	-4.80	0.00
Chen	2012	0.80	0.38	1.71	-0.57	0.57
ADAPT-DES	2012	0.64	0.46	0.88	-2.70	0.01
AVIO	2013	0.46	0.21	0.99	-1.99	0.05
Random pooled estimate		**0.78**	**0.63**	**0.96**	**-2.30**	**0.02**

I^2=58

Odds ratio and 95% CI



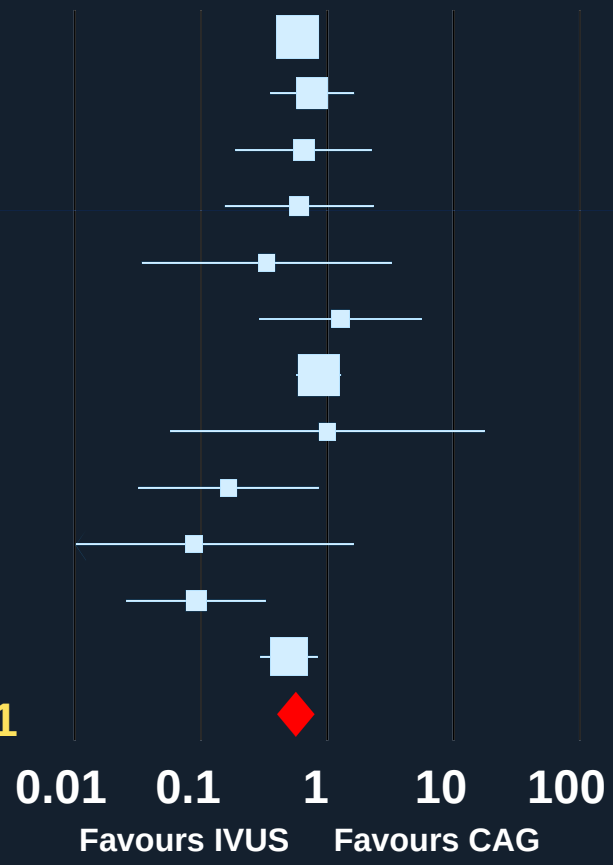
Park SJ, Ahn JM, unpublished data

Stent thrombosis

Study name	Time point	OR	LL	UL	Z-Value	P
Roy	2008	0.58	0.39	0.87	-2.67	0.01
Kim	2010	0.76	0.35	1.67	-0.68	0.50
HOME DES IVUS	2010	0.65	0.18	2.31	-0.66	0.51
MATRIX	2011	0.60	0.15	2.36	-0.74	0.46
COBIS	2011	0.33	0.03	3.30	-0.94	0.35
Youn	2011	1.27	0.28	5.72	0.31	0.76
Hur	2012	0.85	0.56	1.31	-0.72	0.47
EXCELLENT	2012	1.00	0.06	17.87	0.00	1.00
Ahn	2012	0.17	0.03	0.88	-2.11	0.03
Patel	2012	0.09	0.00	1.65	-1.63	0.10
Chen	2012	0.09	0.03	0.33	-3.63	0.00
ADAPT-DES	2012	0.50	0.29	0.85	-2.53	0.01
Random pooled estimate		**0.55**	**0.39**	**0.77**	**-3.43**	**<0.001**

I^2=35

Odds ratio and 95% CI



Park SJ, Ahn JM, unpublished data

FFR guided vs. CAG guided PCI Meta-analysis

A total of 9,301 patients
in 1 randomized trial and 4 observational studies

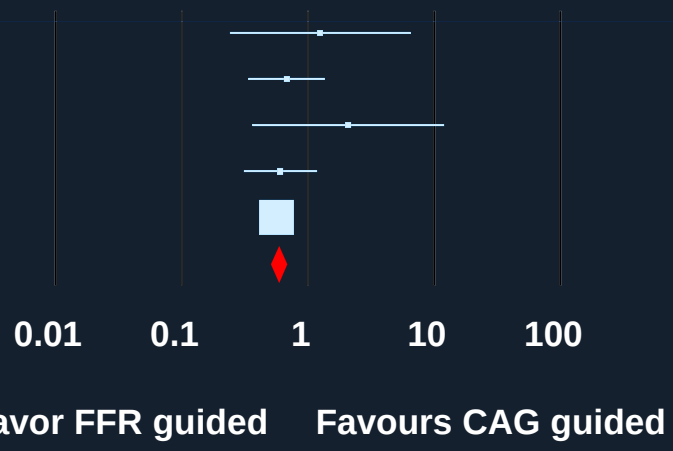
Park SJ, Ahn JM, unpublished data

Death

Study name	Time point	Odds ratio	Lower limit	Upper limit	Z-Value	p-Value
Wongpraparut	2005	1.25	0.24	6.59	0.26	0.80
Pijls	2010	0.68	0.33	1.38	-1.08	0.28
Angkananard	2011	2.09	0.36	12.16	0.82	0.41
Puymirat	2012	0.61	0.30	1.20	-1.44	0.15
Lerman	2013	0.56	0.48	0.66	-7.22	0.00
Random pooled estimate		**0.58**	**0.50**	**0.67**	**-7.27**	**<0.001**

Statistics for each study

$I^2=0$

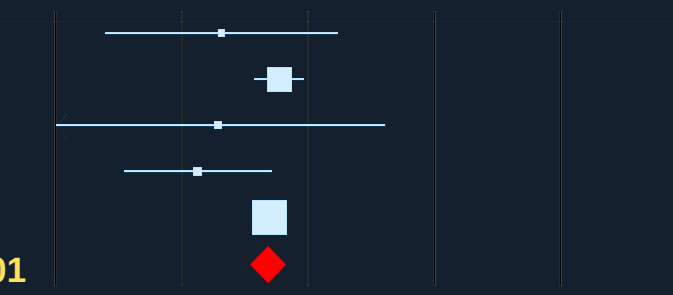


Park SJ, Ahn JM, unpublished data

Myocardial Infarction

Study name	Time point	Statistics for each study				
		Odds ratio	Lower limit	Upper limit	Z-Value	p-Value
Wongpraparut	2005	0.21	0.02	1.75	-1.45	0.15
Pijls	2010	0.59	0.37	0.94	-2.20	0.03
Angkananard	2011	0.20	0.01	4.19	-1.04	0.30
Puymirat	2012	0.13	0.03	0.53	-2.88	0.00
Lerman	2013	0.49	0.39	0.62	-6.04	0.00
Random pooled estimate		**0.47**	**0.34**	**0.65**	**-4.55**	**<0.001**

I^2=21



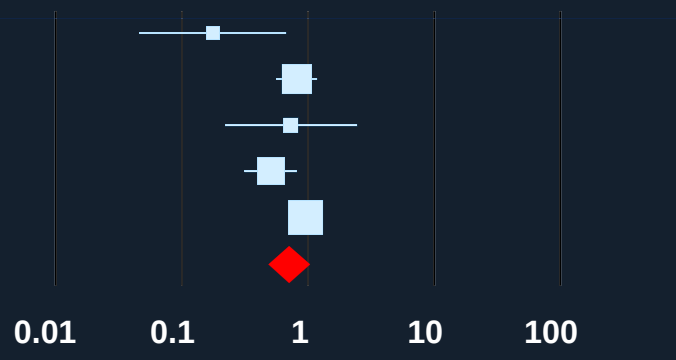
Park SJ, Ahn JM, unpublished data

Repeat revascularization

Study name	Time point	Odds ratio	Lower limit	Upper limit	Z-Value	p-Value
Wongpraparut	2005	0.18	0.05	0.68	-2.51	0.01
Pijls	2010	0.82	0.55	1.20	-1.04	0.30
Angkananard	2011	0.73	0.22	2.49	-0.50	0.62
Puymirat	2012	0.51	0.31	0.83	-2.70	0.01
Lerman	2013	0.96	0.84	1.10	-0.64	0.53
Random pooled estimate		**0.70**	**0.48**	**1.02**	**-1.88**	**0.06**

Statistics for each study

I^2=66

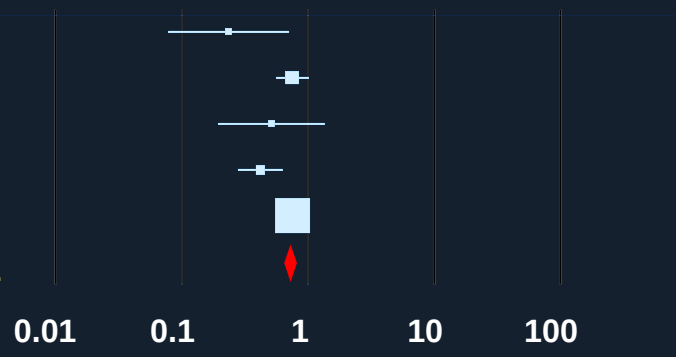


Park SJ, Ahn JM, unpublished data

Death, MI, or Repeat revascularization

Study name	Time point	Statistics for each study				
		Odds ratio	Lower limit	Upper limit	Z-Value	p-Value
Wongpraparut	2005	0.24	0.08	0.72	-2.52	0.01
Pijls	2010	0.76	0.55	1.03	-1.78	0.08
Angkananard	2011	0.51	0.19	1.39	-1.31	0.19
Puymirat	2012	0.42	0.27	0.64	-4.00	0.00
Lerman	2013	0.75	0.66	0.86	-4.29	0.00
Random pooled estimate		**0.71**	**0.64**	**0.80**	**-5.88**	**<0.001**

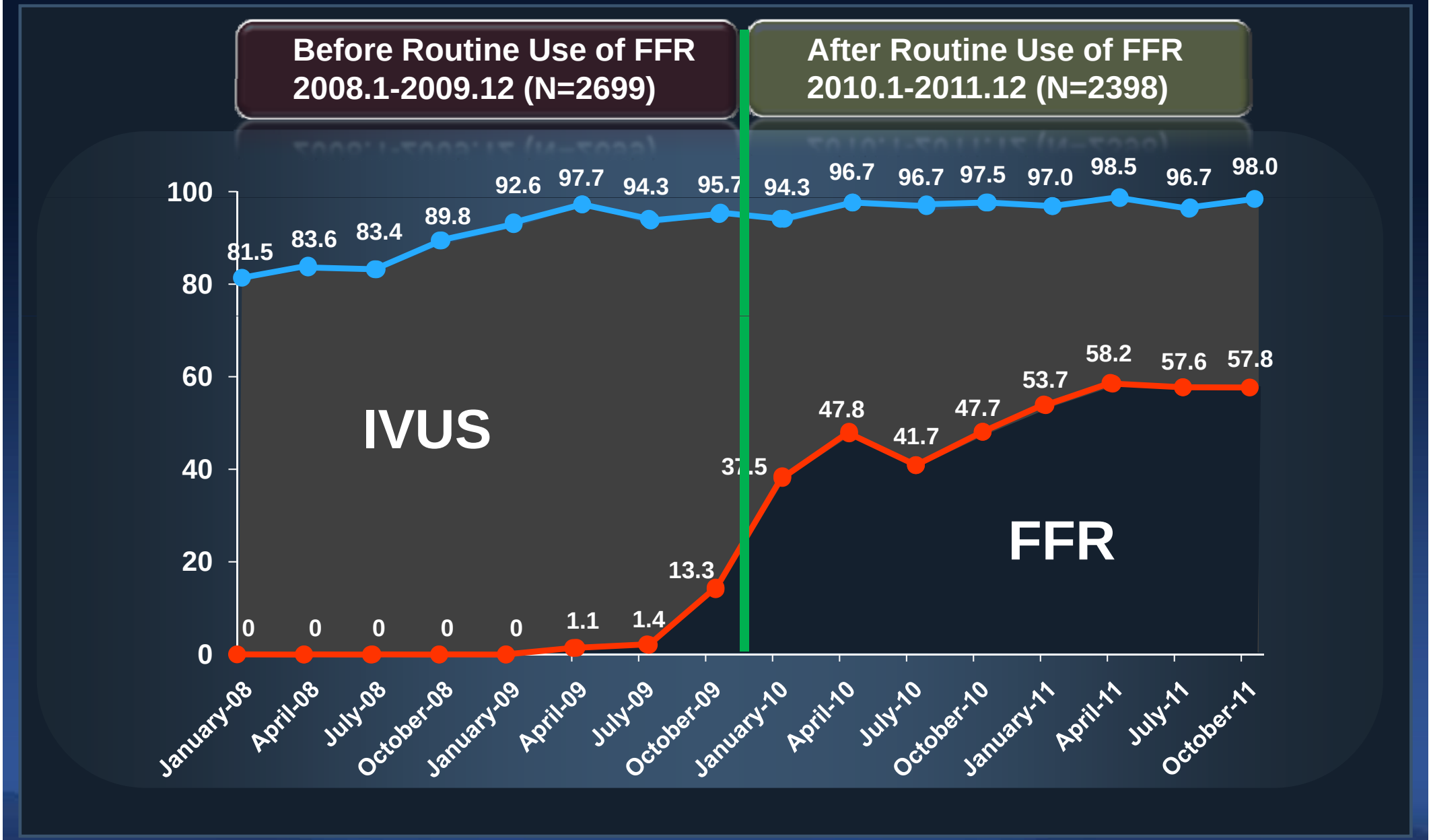
I^2=64



Park SJ, Ahn JM, unpublished data

Clinical Impact of Functional Angioplasty in Asan Medical Center Experience

Rate of FFR and IVUS Use



Baseline Characteristics

	Unadjusted Group			Propensity Matched Group		
	Before Routine FFR (N=2699)	After Routine FFR (N=2398)	P	Before Routine FFR (N=2178)	After Routine FFR (N=2178)	P
Age, year	62.0±9.9	62.6±10.3	0.04	62.4±9.8	62.3±10.3	0.87
Male sex	1982 (70.5)	1685 (74.2)	0.003	1585 (72.8)	1574 (72.3)	0.73
Hypertension	1615 (59.8)	1483 (61.8)	0.15	1328 (61.0)	1333 (61.2)	0.90
DM	834 (30.9)	794 (33.1)	0.09	705 (32.4)	705 (32.4)	>0.99
Current smoker	803 (29.8)	681 (28.4)	0.29	634 (29.1)	632 (29.0)	0.97
Hyperlipidemia	1535 (56.9)	1600 (66.7)	<0.001	1388 (63.7)	1396 (64.1)	0.77
Previous CABG	113 (4.2)	44 (1.8)	<0.001	51 (2.3)	44 (2.0)	0.40
Previous MI	154 (5.7)	112 (4.7)	0.10	106 (4.9)	108 (5.0)	0.95
Previous PCI	473 (17.5)	411 (17.1)	0.72	369 (16.9)	363 (16.7)	0.84

Baseline Characteristics

	Unadjusted Group			Propensity Matched Group		
	Before Routine FFR (N=2699)	After Routine FFR (N=2398)	P	Before Routine FFR (N=2178)	After Routine FFR (N=2178)	P
Previous CHF	20 (0.7)	26 (1.1)	0.20	19 (0.9)	22 (1.0)	0.76
Previous stroke	153 (5.7)	149 (6.2)	0.41	131 (6.0)	126 (5.8)	0.79
Peripheral vascular Dz	46 (1.7)	59 (2.5)	0.06	46 (1.9)	44 (2.0)	0.91
Chronic renal failure	67 (2.5)	82 (3.4)	0.05	57 (2.6)	59 (2.7)	0.92
COPD	36 (1.3)	57 (2.4)	0.005	36 (1.7)	30 (1.4)	0.53
LVEF, %	58.7±7.9	59.2±9.1	0.09	58.7±7.9	59.2±9.1	0.37
Clinical presentation			0.18			0.10
Stable angina	1687 (62.5)	1552 (64.7)		1394 (64.0)	1411 (64.8)	
Unstable angina	750 (27.8)	642 (26.8)		582 (26.7)	584 (26.8)	
AMI	262 (9.7)	204 (8.5)		202 (9.3)	183 (8.4)	

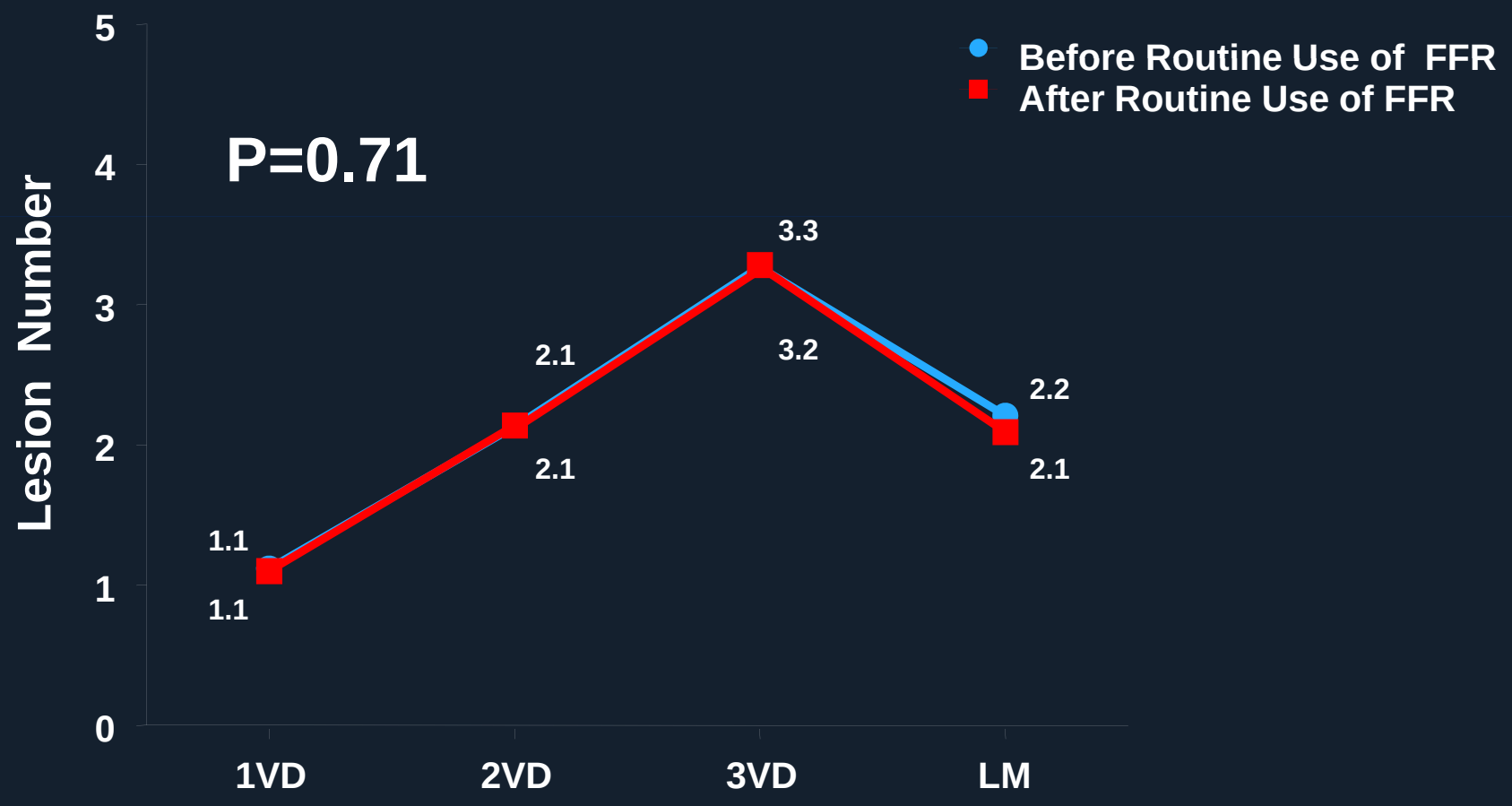
Baseline Characteristics

	Unadjusted Group			Propensity Matched Group		
	Before Routine FFR (N=2699)	After Routine FFR (N=2398)	P	Before Routine FFR (N=2178)	After Routine FFR (N=2178)	P
Extent			0.21			0.38
1VD	1216 (45.1)	1138 (47.5)		994 (45.6)	1051 (48.3)	
2VD	787 (29.2)	644 (26.9)		637 (29.2)	570 (26.2)	
3VD	377 (14.0)	346 (14.4)		313 (14.4)	306 (14.0)	
LMCA stenosis	319 (11.8)	270 (11.3)		234 (10.7)	251 (11.5)	
Bifurcation	1242 (46.0)	1048 (43.7)	0.10	1205 (55.3)	1200 (55.1)	0.90
Restenotic lesion	207 (7.7)	173 (7.2)	0.54	155 (7.1)	151 (6.9)	0.86
Long lesion (>20mm)	2215 (82.1)	1879 (78.4)	0.001	1742 (80.0)	1748 (80.3)	0.84
CTO	148 (5.5)	177 (7.4)	0.006	141 (6.5)	129 (5.9)	0.48
Calcified lesion	214 (7.9)	157 (6.5)	0.06	147 (6.7)	144 (6.6)	0.90

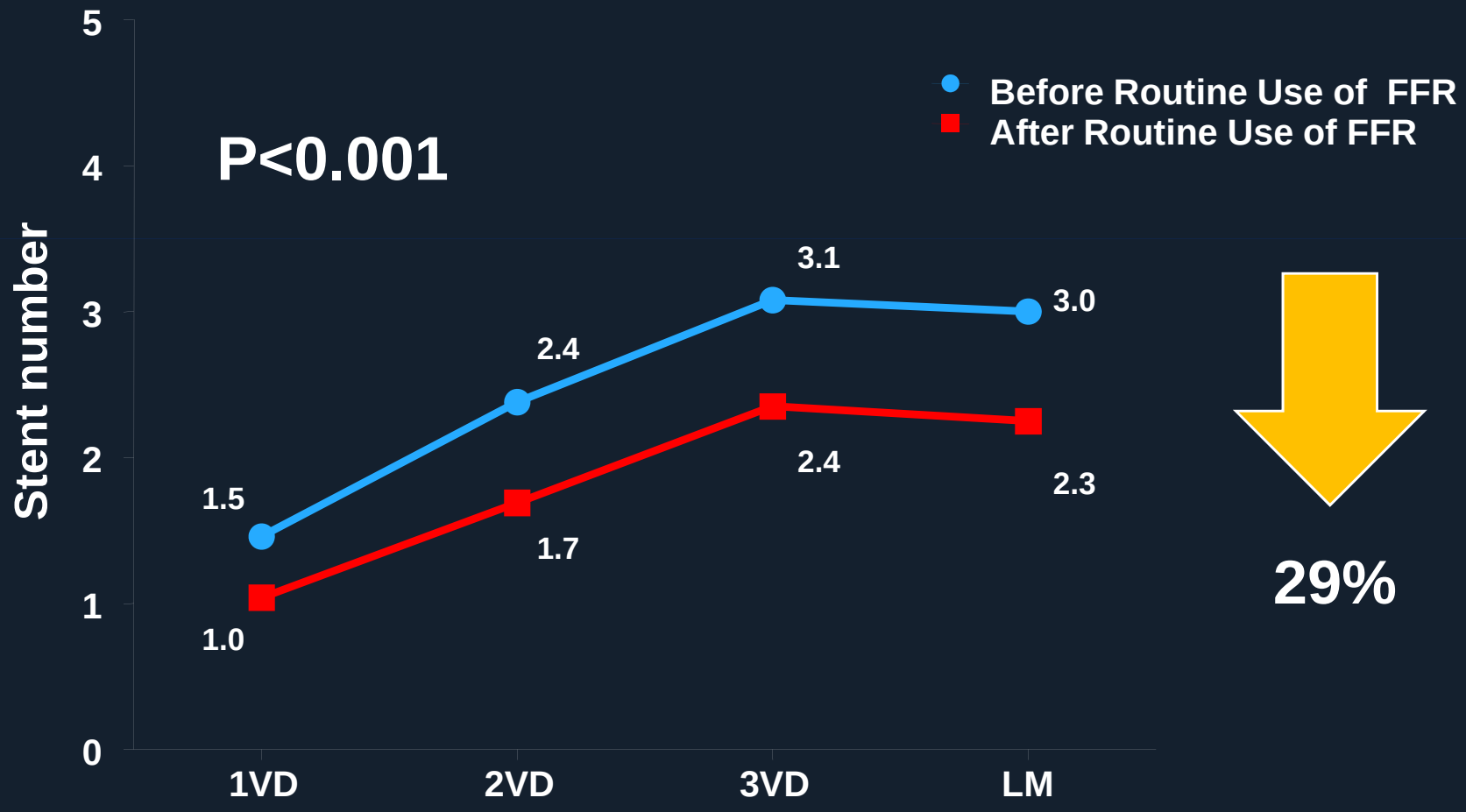
Procedural Characteristics

	Before Routine FFR (N=2178)	After Routine FFR (N=2178)	P value
Fractional flow reserve	47 (2.2)	1093 (50.2)	<0.001
Intravascular ultrasound	1967 (90.3)	2114 (97.1)	<0.001
No. of lesions	1.8±0.9	1.8±1.0	0.71
No. of treated lesions	1.4±0.7	1.1±0.8	<0.001
No. of stents	2.1±1.3	1.5±1.2	<0.001
Total stent length, mm	53.7±36.1	40.1±34.1	<0.001
Average stent diameter, mm	3.3±0.3	3.3±0.4	0.31
Multivessel stenting	772 (35.4)	563 (25.8)	<0.001

Changes in PCI procedure

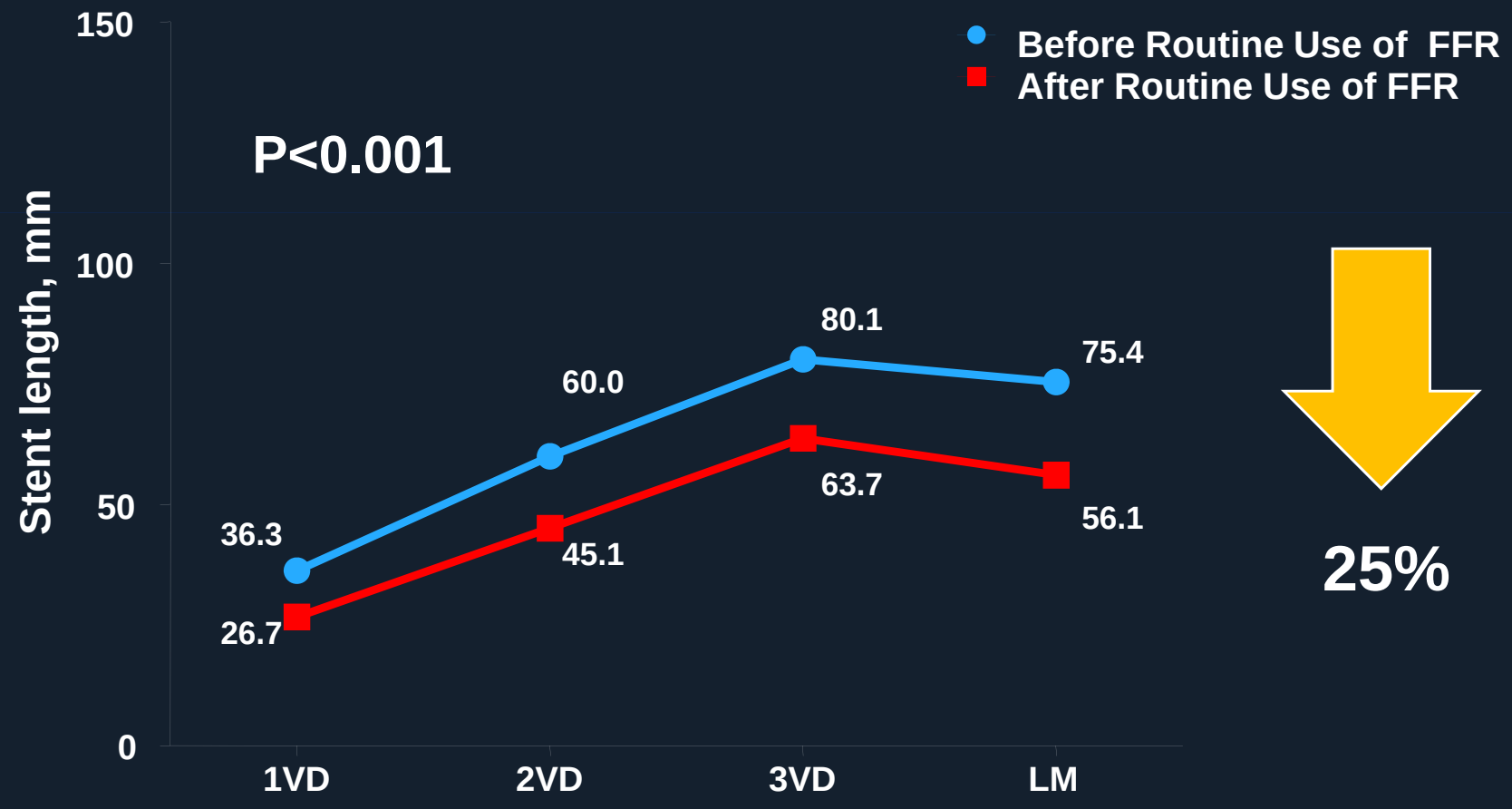


Changes in PCI procedure



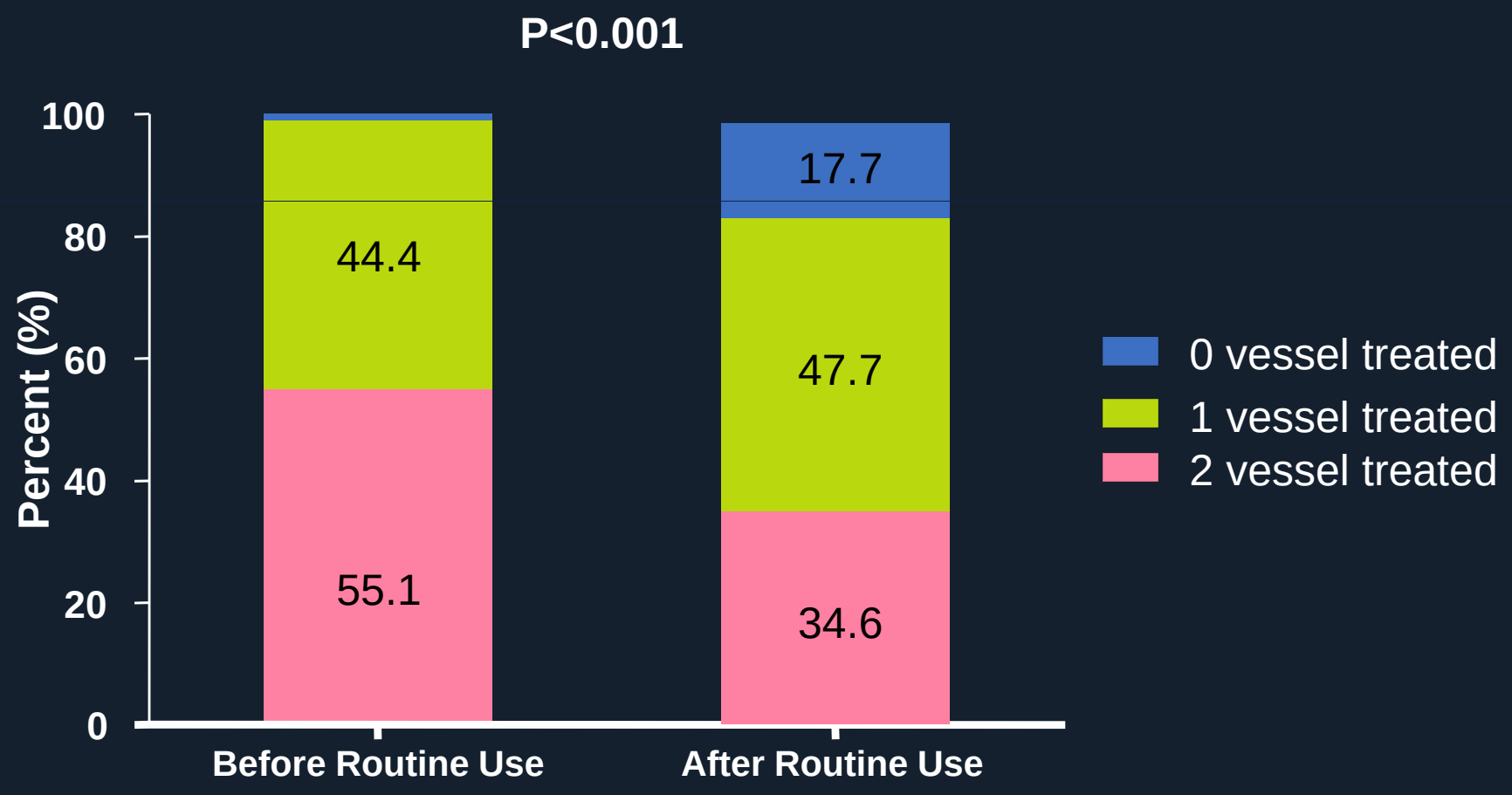
Changes in PCI procedure

Stent Length

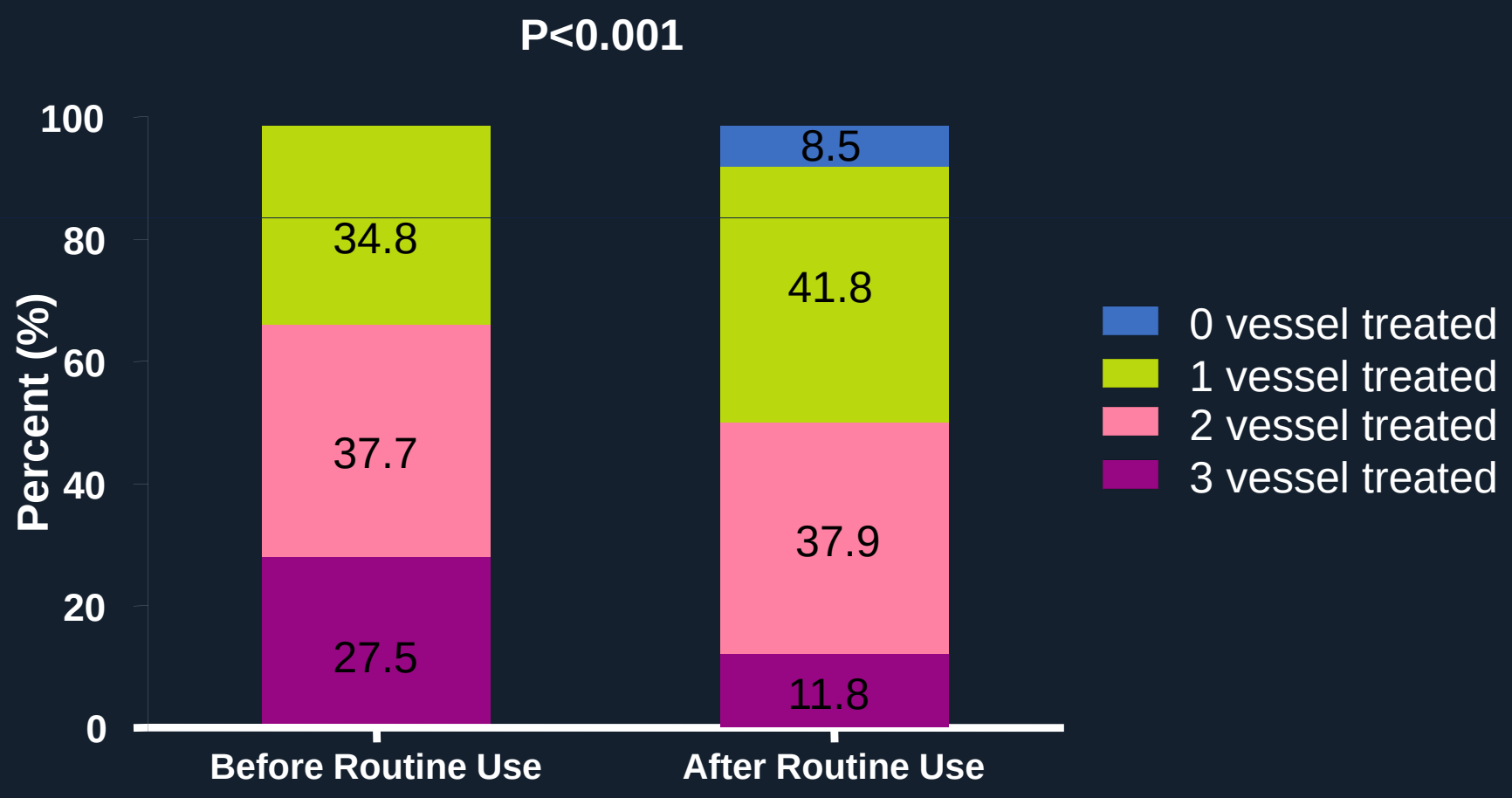


Changes in PCI procedure

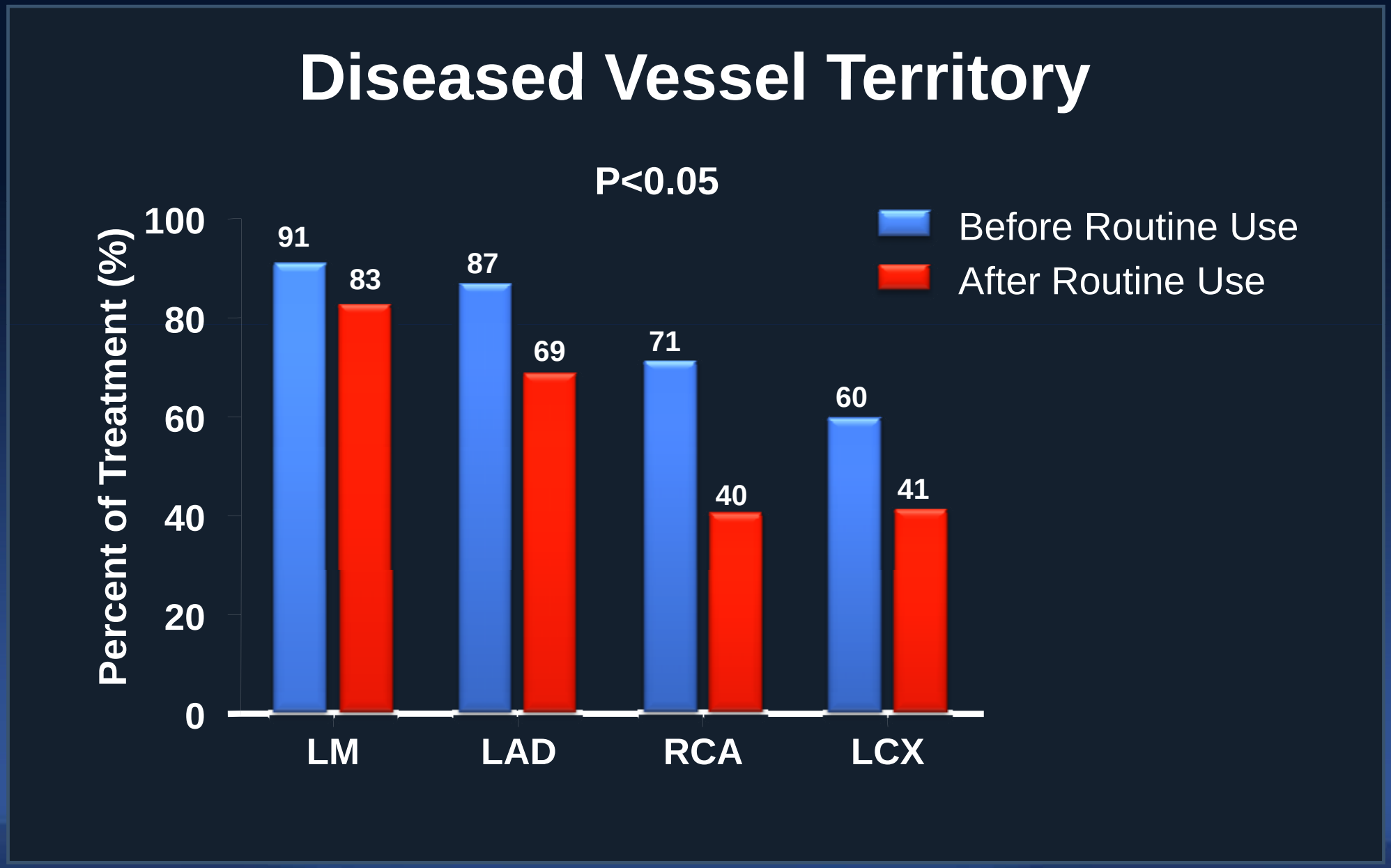
Two Vessel Disease



Changes in PCI procedure

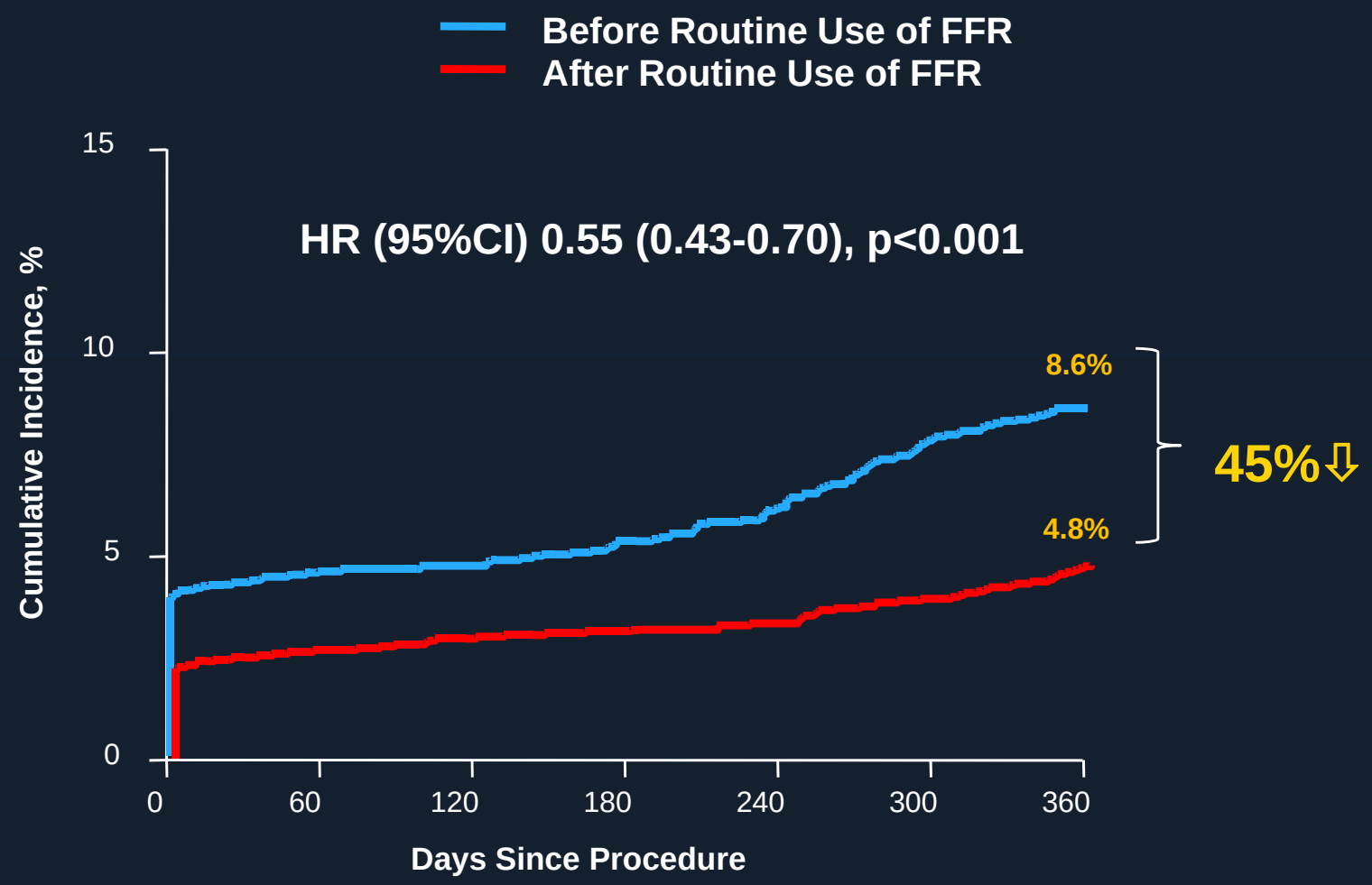


Changes in PCI procedure



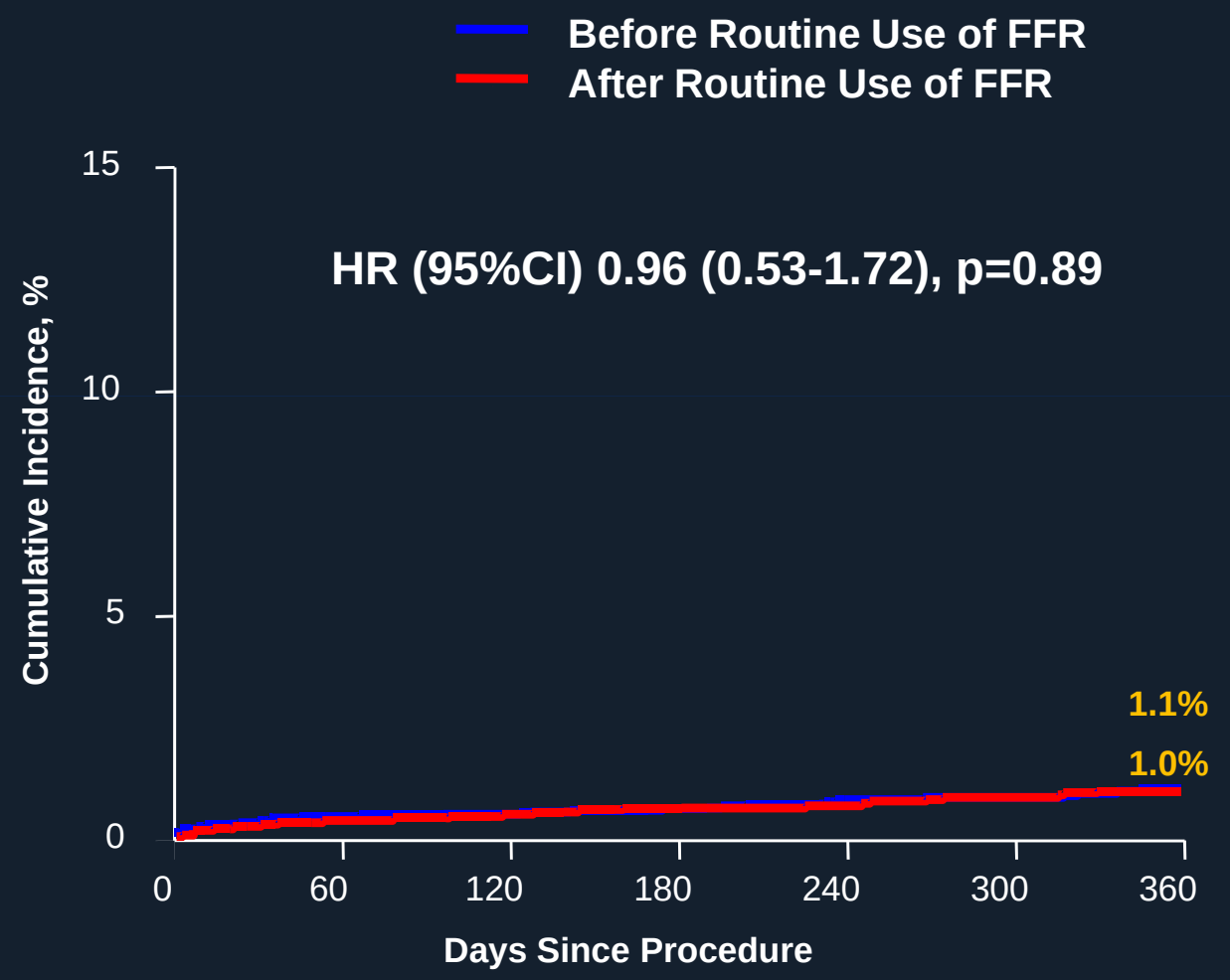
Primary End Point

(Death, MI, or Repeat Revascularization)



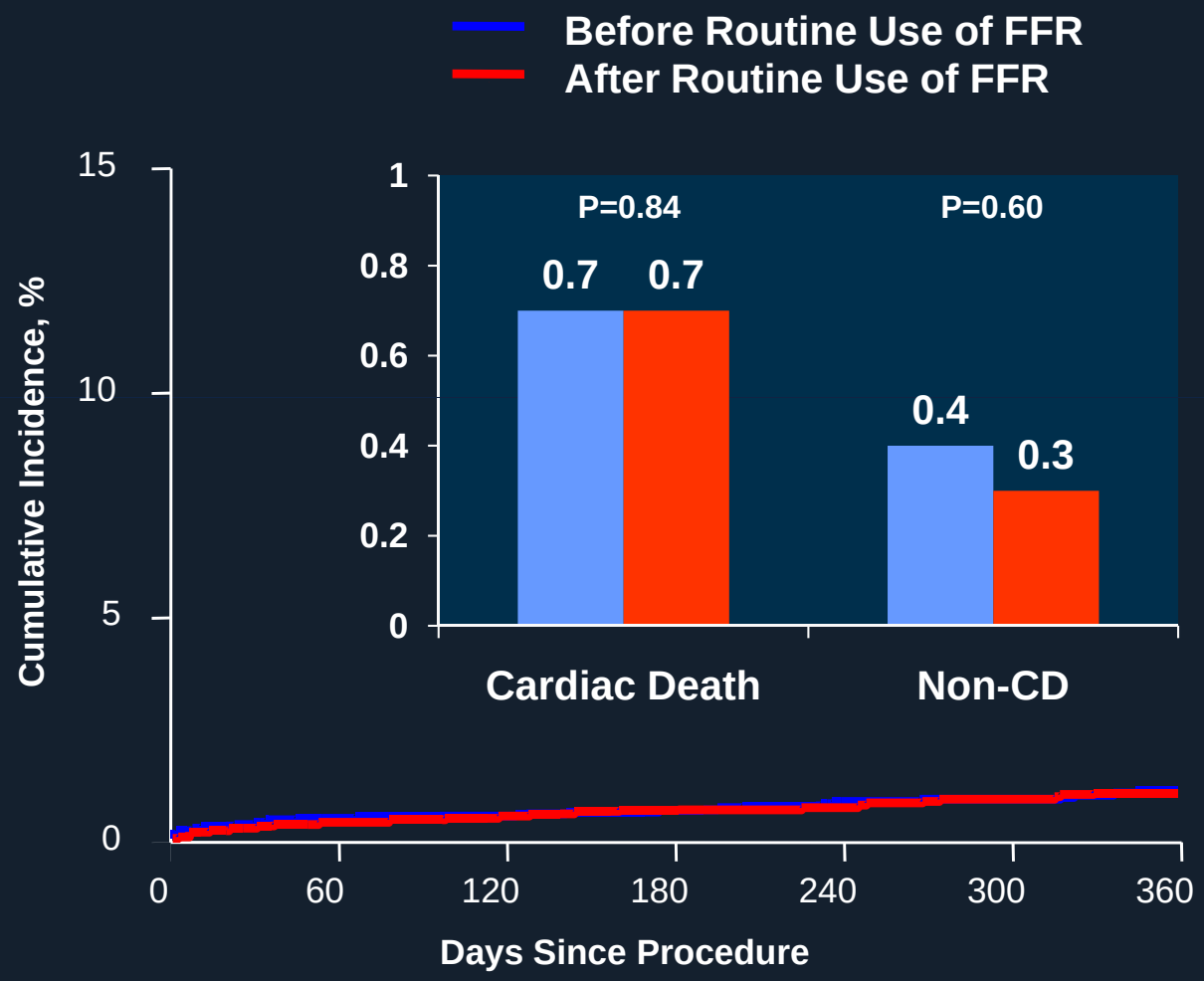
No. at Risk				
Before Routine Use	2178	2066	2011	1960
After Routine Use	2178	2092	2067	2037

Death



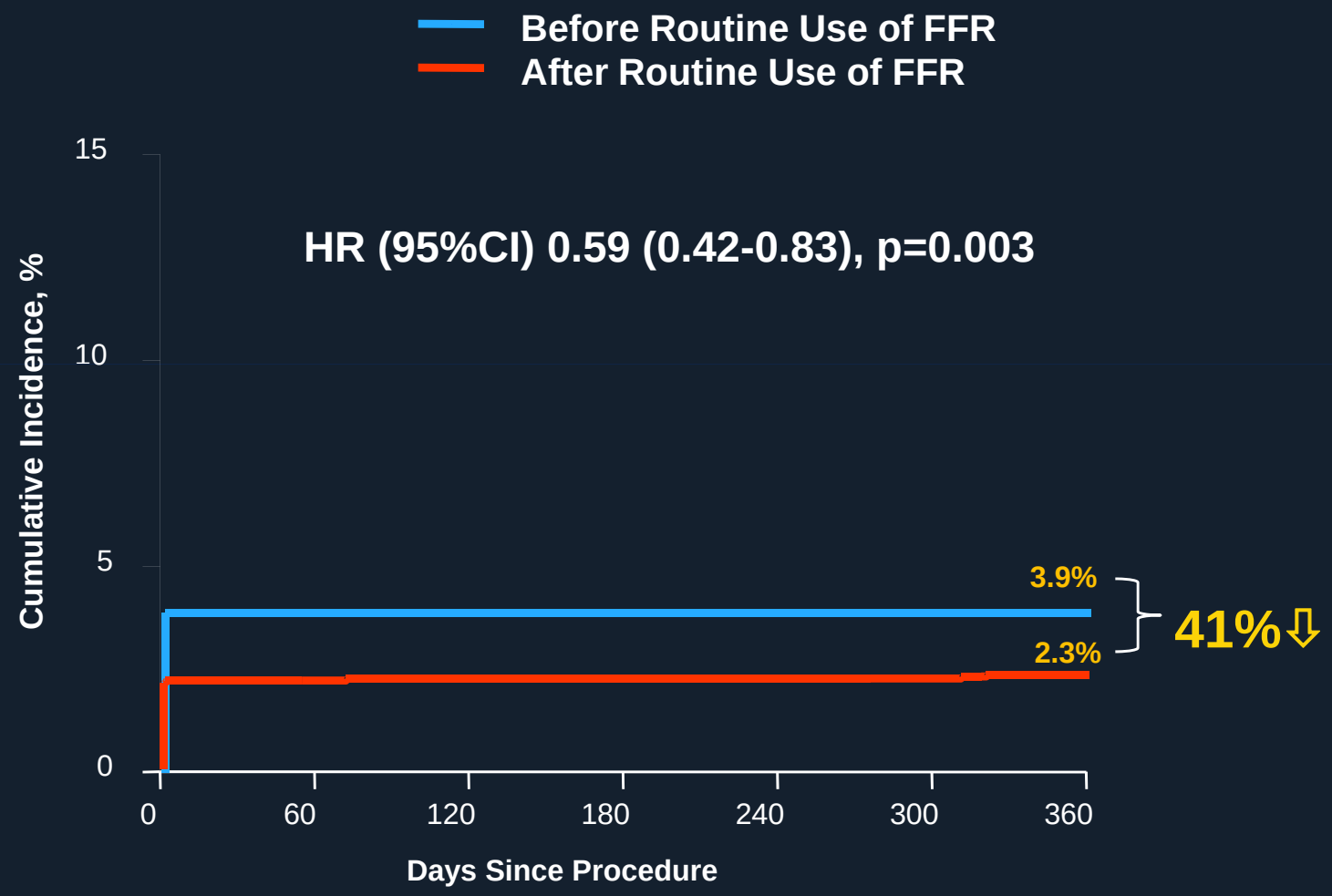
No. at Risk				
Before Routine Use	2178	2156	2126	2121
After Routine Use	2178	2143	2120	2113

Death



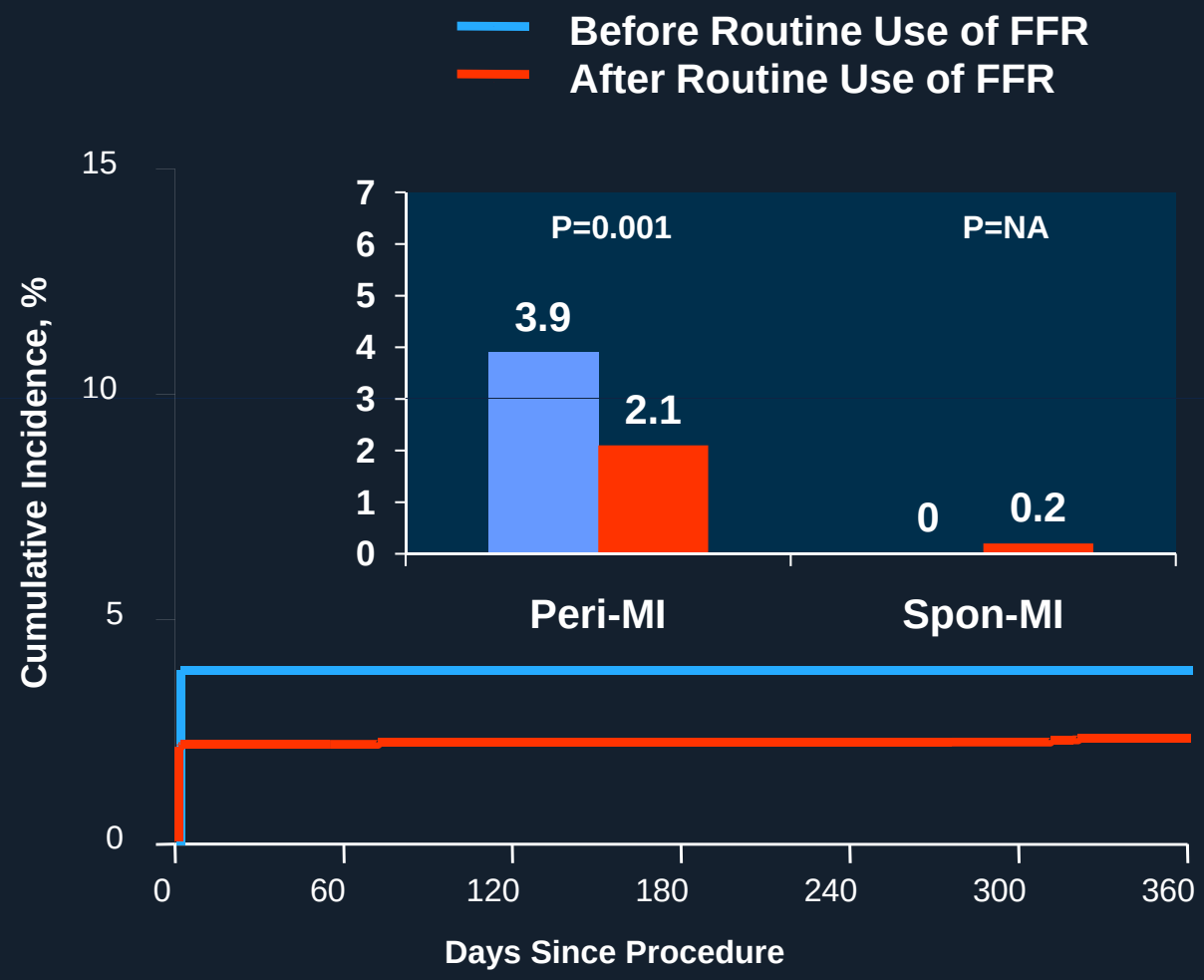
No. at Risk				
Before Routine Use	2178	2156	2126	2121
After Routine Use	2178	2143	2120	2113

Myocardial Infarction



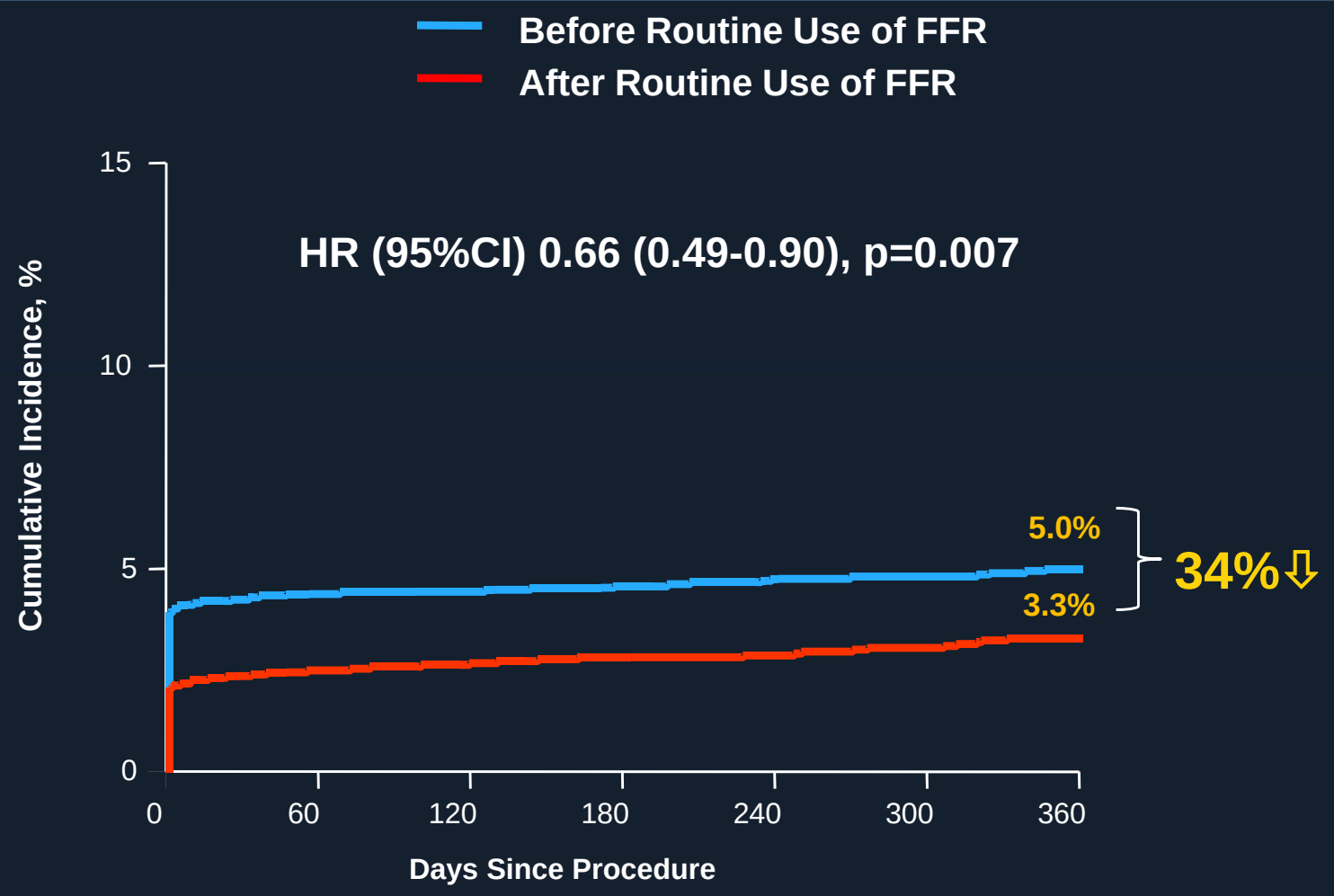
No. at Risk				
Before Routine Use	2178	2071	2041	2036
After Routine Use	2178	2098	2075	2066

Myocardial Infarction



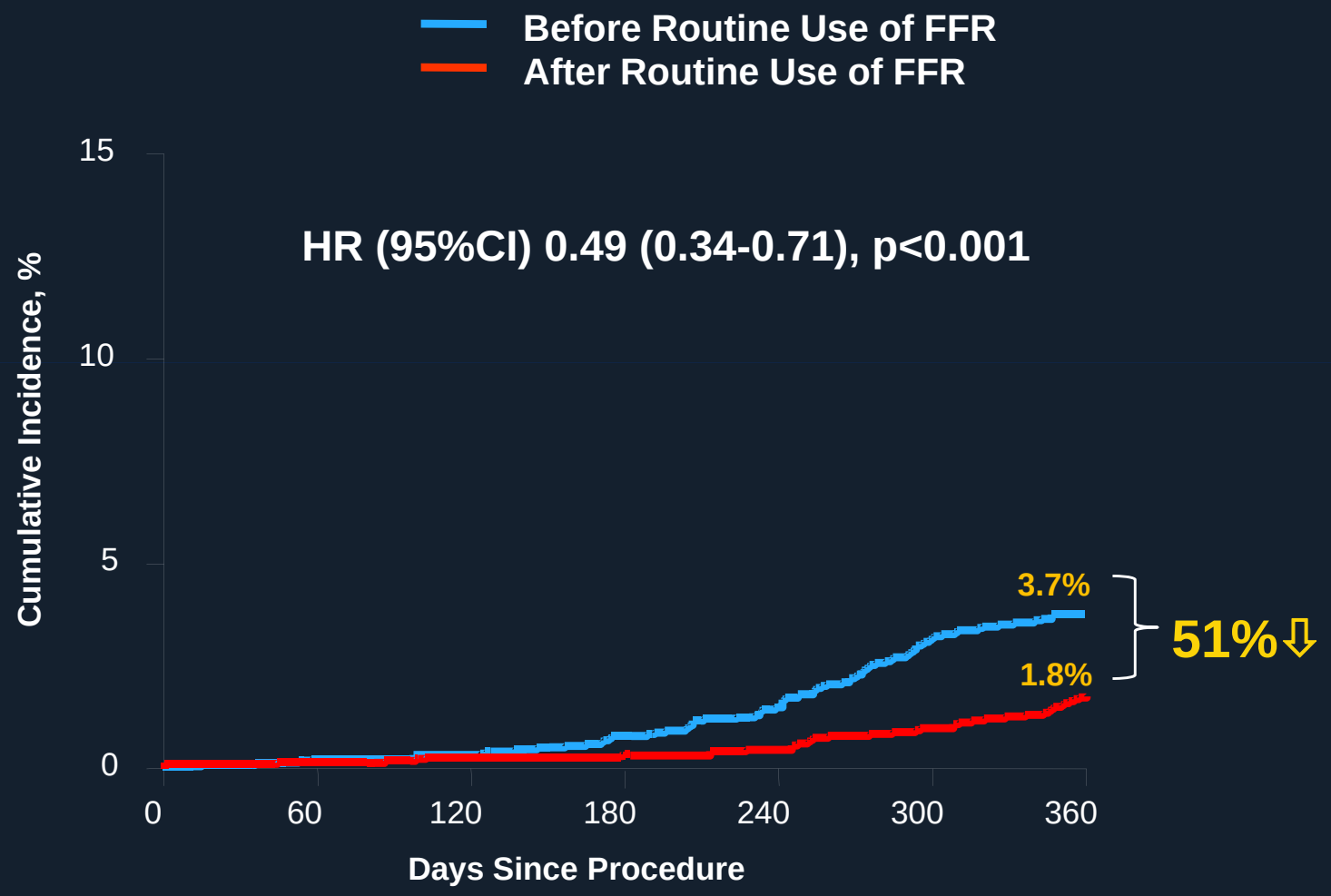
No. at Risk				
Before Routine Use	2178	2071	2041	2036
After Routine Use	2178	2098	2075	2066

Death or Myocardial Infarction



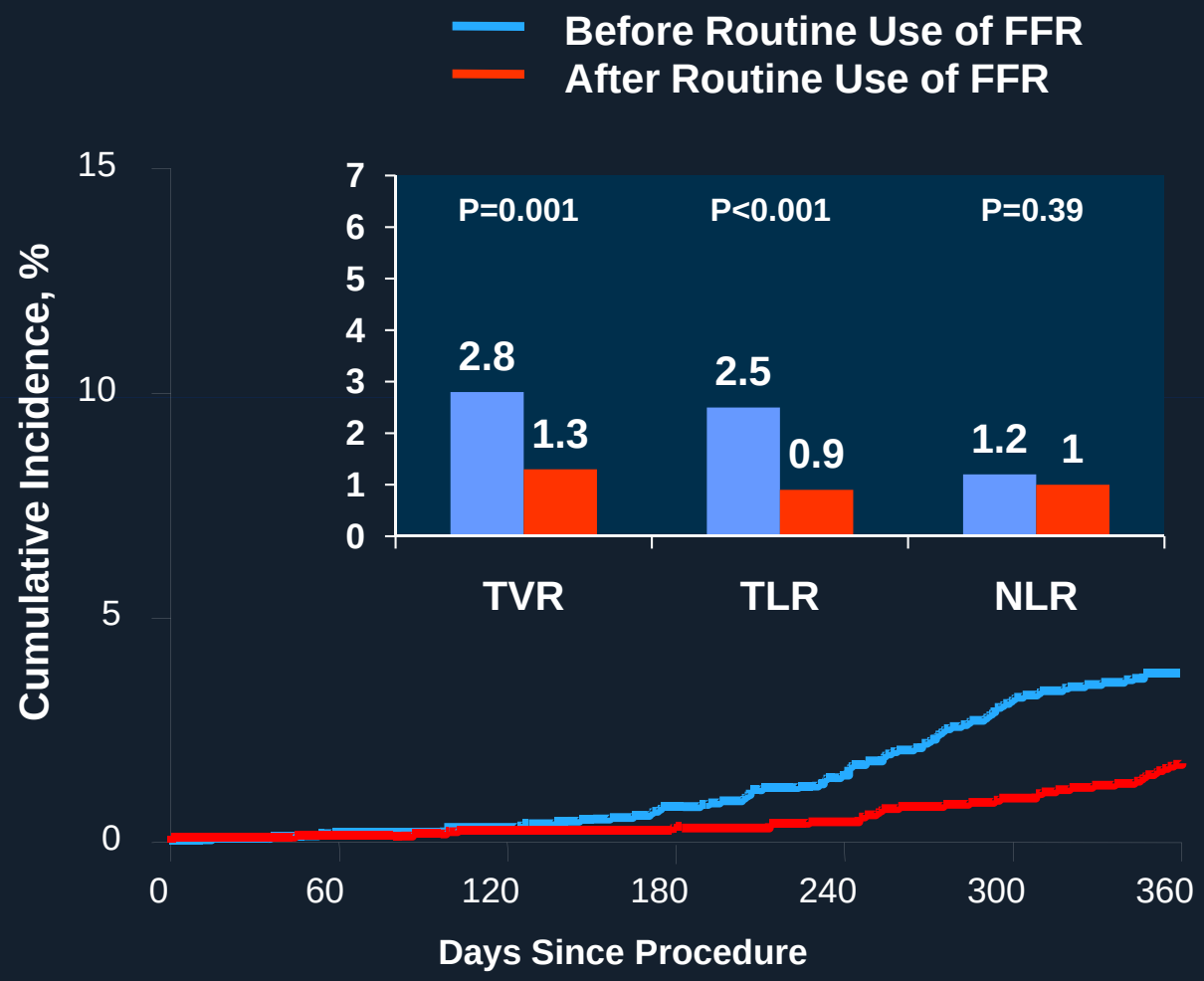
No. at Risk				
Before Routine Use	2178	2071	2041	2036
After Routine Use	2178	2098	2075	2066

Repeat Revascularization



No. at Risk				
Before Routine Use	2178	2151	2095	2048
After Routine Use	2178	2136	2110	2083

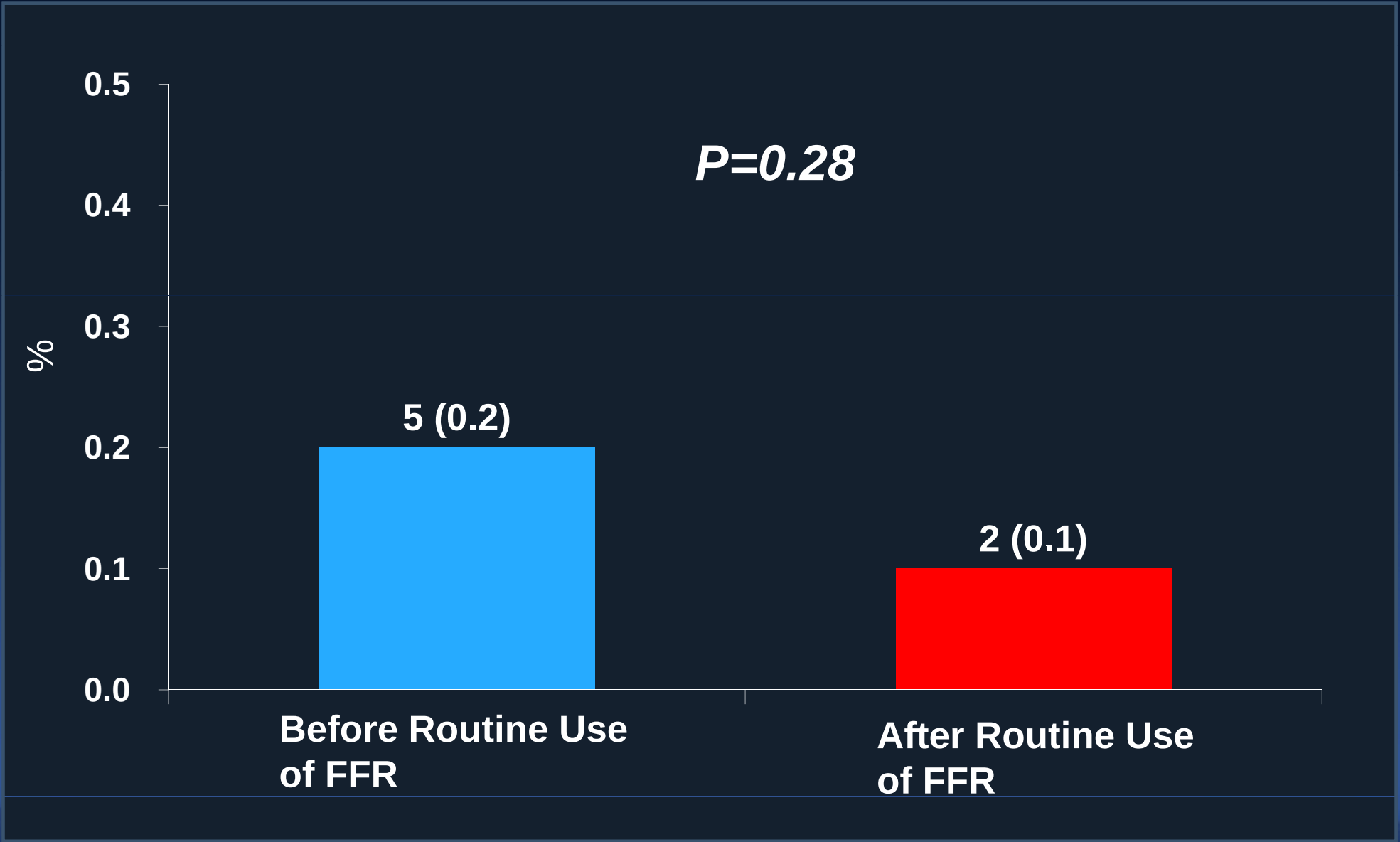
Repeat Revascularization



No. at Risk

Before Routine Use	2178	2151	2095	2048
After Routine Use	2178	2136	2110	2083

Stent Thrombosis at 12 Months*



* ARC defined definite and probable stent thrombosis

One-Year Outcomes of Patients and FFR-Assessed Lesions

FFR was measured in 1267 patients (1551 lesions) during study period

Deferred of PCI	Performed PCI at any lesion
475 patients (575 lesions)	792 patients (976 lesions)
	412 lesions deferred 564 lesions stented

1 year clinical outcomes

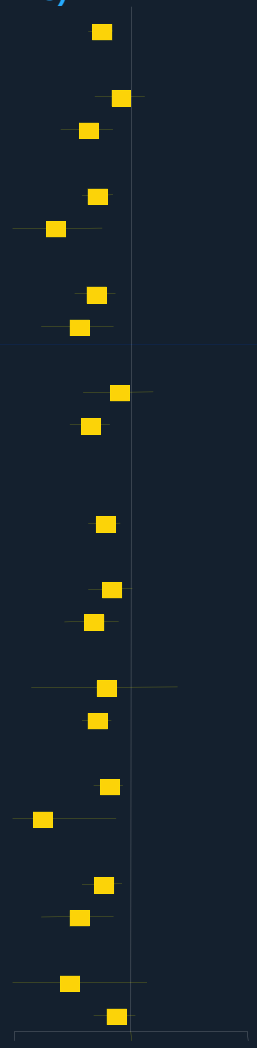
Non-cardiac death: 1 patient **Repeat revascularization: 2 patients (3 lesions)**	**Cardiac death: 1 patient** **Non-cardiac death: 2 patients** **Repeat revascularization: 19 patients (21 lesions*)**

*** 3 revascularizations were associated with deferred lesions.**

Propensity Score Matched Population

Subgroup Analysis

Subgroup	Event Rate (%) of Primary Endpoints: Before Routine Use (N=2178)	Event Rate (%) of Primary Endpoints: After Routine Use (N=2178)	Hazard Ratio (95% CI)	P value	Interaction P value
Overall	8.6	4.8	0.55 (0.43, 0.70)	<0.001	
Age					0.08
≥65 yo (N=1917)	8.7	6.0	0.80 (0.49, 1.32)	0.38	
<65 yo (N=2439)	8.4	3.8	0.42 (0.25, 0.70)	0.001	
Sex					0.74
Male (N=3159)	8.4	4.7	0.50 (0.38, 0.70)	<0.001	
Female (N=1197)	8.9	5.0	0.22 (0.08, 0.57)	0.002	
Presentation					0.82
sAP (N=2805)	7.7	4.3	0.49 (0.33, 0.74)	0.001	
ACS (N=1551)	10.0	5.7	0.35 (0.17, 0.71)	0.004	
Diabetes					0.12
Yes (N=1410)	9.6	6.1	0.78 (0.39, 1.56)	0.48	
No (N=2946)	8.1	4.2	0.44 (0.30, 0.66)	<0.001	
Ejection fraction					NA
≤40% (N=154)	13.3	6.5	NA	NA	
>40% (N=3840)	7.9	4.9	0.63 (0.48, 0.83)	0.001	
Bifurcation					0.27
Yes (N=1951)	11.2	7.2	0.67 (0.43, 1.03)	0.067	
No (N=2405)	6.4	2.8	0.47 (0.27, 0.79)	0.005	
Left main disease					0.56
Yes (N=485)	15.0	10.9	0.60 (0.14, 2.51)	0.48	
No (N=3871)	7.8	4.0	0.50 (0.38, 0.68)	<0.001	
Long (>20mm) lesion					0.044
Yes (N=3490)	9.2	5.4	0.64 (0.48, 0.85)	0.002	
No (N=866)	6.0	2.1	0.17 (0.04, 0.75)	0.019	
Multivessel disease					0.48
Yes (N=2311)	6.5	3.8	0.57 (0.38, 0.84)	0.005	
No (N=2045)	2.8	2.1	0.35 (0.17, 0.71)	0.004	
Type of DES					0.30
Previous DES (N=1589)	8.1	2.4	0.29 (0.06, 1.38)	0.12	
New DES (N=2351)	9.5	6.2	0.73 (0.48, 1.09)	0.13	



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After Rouinte Favor

Before Rouinte Favor

Independent Predictors of Primary End Point

	Hazard Ratio (95% CI)	P value
Chronic renal failure	2.41 (1.61-3.59)	<0.001
Multivessel disease	1.89 (1.45-2.46)	<0.001
Peripheral vascular disease	1.84 (1.07-3.17)	0.027
Bifurcation lesion	1.37 (1.09-1.71)	0.006
Acute coronary syndrome	1.37 (1.10-1.69)	0.004
Total stent length per patient	1.01 (1.00-1.01)	<0.001
Fractional flow reserve	0.72 (0.53-0.98)	0.036
Intravascular ultrasound	0.57 (0.40-0.81)	0.002

Conclusion

- The current study confirmed the benefit of FFR-guided PCI in a real-world patient population.
- Temporal comparison of two cohorts using propensity-score matching showed that the risks of death, MI, or repeat revascularization at 1 year were significantly reduced when FFR is used routinely.
- The benefit is primarily due to a reduced number of stents used per patients and a subsequent decreased risk of peri-procedrual MI and repeat revascularization.

Conclusion

- Profound reduction of stent used was observed in the territory of RCA and LCX, which can be explained by the higher incidence of “visual-functional mismatch” in this territory.
- The routine measurement of FFR in daily practice appeared to be associated with a more judicious use of stent implantation and improvement in clinical outcomes at 1 year.