

## Supplementary Online Content

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This supplementary material has been provided by the authors to give readers additional information about their work.

**eTable 1.** Demographic and clinical characteristics of patients undergoing ULM PCI over time

	<b>2009Q3- 2011Q2</b>	<b>2011Q3- 2013Q2</b>	<b>2013Q3- 2015Q2</b>	<b>2015Q3- 2016Q2</b>	<b>P</b>
	N = 6686	N = 8954	N = 10659	N = 6829	
<b>Demographics</b>					
Age	71.6 ± 12.4	71.2 ± 12.6	72.1 ± 12.3	72.6 ± 12.1	<0.001
Male gender	3996 (59.8)	5402 (60.3)	6425 (60.3)	4052 (59.3)	0.54
Race					
White	5904 (88.3)	7705 (86.1)	9140 (85.7)	5846 (85.6)	<0.001
African Am.	423 (6.3)	646 (7.2)	850 (8.0)	494 (7.2)	0.06
Asian	222 (3.3)	384 (4.0)	415 (3.9)	283 (4.1)	0.26
Other	67 (1.0)	118 (1.3)	122 (1.1)	94 (1.3)	0.28
Hispanic ethnicity	347 (5.2)	498 (5.6)	596 (5.6)	418 (6.1)	0.13
Insurance payor					
None	180 (2.7)	324 (3.6)	284 (2.7)	151 (2.2)	<0.001
Private	4136 (61.9)	5658 (63.2)	6800 (63.8)	4351 (63.7)	0.056
Medicare	4639 (69.4)	6067 (67.8)	7512 (70.5)	4895 (71.7)	<0.001
Medicaid	733 (11.0)	1016 (11.3)	1307 (12.3)	874 (12.8)	0.02
Military	218 (3.3)	279 (3.0)	371 (3.5)	241 (3.5)	0.22
Other	115 (1.7)	121 (1.3)	152 (1.4)	113 (1.7)	0.29
<b>History</b>					
Current tobacco	1313 (19.7)	1768 (19.8)	2063 (19.4)	1304 (19.1)	0.71
Hypertension	5679 (84.9)	7666 (85.6)	9189 (86.2)	4963 (87.3)	<0.001
Dyslipidemia	5246 (81.4)	7267 (81.3)	8625 (81.1)	5529 (81.0)	0.94
Family History CAD <sup>b</sup>	1164 (17.4)	1599 (17.9)	1643 (15.4)	912 (13.4)	<0.001
Prior MI <sup>c</sup>	2197 (32.9)	3006 (33.6)	3698 (34.7)	2361 (34.6)	0.05
Prior Heart Failure	1629 (24.4)	2307 (25.8)	3136 (29.4)	2104 (30.8)	<0.001
Prior PCI	2537 (37.9)	3292 (36.8)	3980 (37.3)	2593 (38.0)	0.34
ESRD <sup>d</sup> on Dialysis	332 (5.0)	484 (5.4)	601 (5.6)	432 (6.3)	0.01
GFR <sup>e</sup> (mean ± SD)	64.7 ± 20.2	66.0 ± 20.6	65.9 ± 20.8	65.5 ± 20.9	<0.001
Cerebrovascular Disease	1425 (21.3)	1869 (20.9)	2330 (21.9)	1529 (22.4)	0.11
Peripheral Arterial Disease	1493 (22.3)	1910 (21.3)	2337 (21.9)	1484 (21.7)	0.50

Chronic Lung Disease	1597 (23.9)	2210 (24.7)	2643 (24.8)	1656 (24.2)	0.52
Diabetes Mellitus	2568 (38.4)	3567 (39.8)	4369 (41.0)	2864 (41.9)	<0.001
<b>Presentation</b>					
PCI Status					
Elective	2779 (41.6)	3262 (36.4)	3392 (31.8)	2062 (30.2)	<0.001
Urgent	3203 (47.9)	4739 (52.9)	6090 (57.2)	4059 (59.5)	
Emergent	652 (9.8)	893 (10.0)	1073 (10.1)	647 (9.5)	
Salvage	49 (0.7)	59 (0.7)	97 (0.9)	58 (0.8)	
CAD presentation					
No symptoms	966 (14.5)	893 (10.0)	877 (8.2)	538 (7.9)	<0.001
Unlikely ischemic	179 (7.2)	204 (2.3)	279 (2.6)	198 (2.9)	
Stable angina	1076 (16.1)	1263 (14.1)	1292 (12.1)	788 (11.5)	
Unstable Angina	2607 (39.0)	3797 (42.4)	4562 (42.8)	2915 (42.7)	
Non-STEMI	1427 (21.4)	2163 (24.2)	2867 (26.9)	1907 (27.9)	
STEMI	428 (6.4)	631 (7.0)	781 (7.3)	481 (7.0)	
CCS <sup>f</sup> Class (2 weeks)					
0	1205 (18.1)	1177 (13.2)	1278 (12.0)	849 (12.4)	<0.001
1	352 (5.3)	264 (3.0)	201 (1.9)	95 (1.4)	
2	1143 (17.1)	1086 (12.1)	957 (9.0)	548 (8.0)	
3	2147 (32.2)	3165 (35.4)	3786 (25.6)	2459 (36.1)	
4	1818 (27.3)	3247 (36.3)	4423 (41.6)	2869 (42.1)	
Anti-anginal medications	5011 (75.0)	7207 (80.5)	8781 (82.4)	5668 (83.1)	<0.001
Heart Failure	1632 (24.4)	2408 (26.9)	3420 (32.1)	2356 (34.5)	<0.001
Cardiomyopathy	1342 (20.1)	2010 (22.5)	2643 (24.8)	1860 (27.2)	<0.001
<b>Risk Model</b>					
Cath PCI Mortality (%; mean ± SD)	2.2 ± 7.5	2.2 ± 7.2	2.4 ± 7.9	2.5 ± 8.2	0.02

All values reported as n (%) unless otherwise specified.

a ULM PCI = unprotected left main coronary artery percutaneous coronary intervention

b CAD = coronary artery disease

c MI = myocardial infarction

d ESRD = end-stage renal disease

**eTable 2.** Procedural characteristics of ULM PCI over time

	<b>2009Q3- 2011Q2</b>	<b>2011Q3- 2013Q2</b>	<b>2013Q3- 2015Q2</b>	<b>2015Q3- 2016Q2</b>	<b>P</b>
	N = 6696	N = 8954	N = 10659	N = 6829	
Arterial Access Site					
Femoral	6319 (94.5)	7998 (89.3)	8815 (82.7)	5403 (79.1)	<0.001
Brachial	45 (0.7)	52 (0.6)	59 (0.6)	24 (0.4)	
Radial	315 (4.7)	890 (9.9)	1735 (16.3)	1383 (20.3)	
MCS <sup>a</sup>	1511 (22.6)	2071 (23.1)	2592 (24.3)	1995 (29.2)	<0.001
IABP	1055 (15.8)	1275 (14.2)	1402 (13.2)	806 (11.8)	<0.001
Other MCS	529 (7.9)	898 (10.0)	1315 (12.3)	1281 (18.8)	<0.001
Contrast Volume (mL; mean ± SD)	231.2 ± 122	219.6 ± 114.5	212.0 ± 111.8	207.0 ± 107.6	<0.001
Fluoroscopy Time (minutes; mean ± SD)	22.0 ± 15.4	22.3 ± 16.2	23.3 ± 16.6	24.3 ± 17.1	<0.001
<b>Lesion</b>					
Class C	4901 (73.3)	6555 (73.2)	7721 (73.6)	3691 (75.6)	0.012
LMCA bifurcation					
1 Stent					
>1 Stent					
Lesion treated previously					
Restenosis	523 (7.8)	687 (7.7)	761 (7.3)	347 (7.1)	0.34
Stent thrombosis	47 (0.7)	54 (0.6)	85 (0.8)	32 (0.7)	0.37
Lesion length (mm; mean ± SD)	46.2 ± 48.5	48.2 ± 49.9	53.9 ± 56.5	57.2 ± 59.8	<0.001
Number of lesions treated (mean ± SD)	2.1 ± 1.2	1.9 ± 1.1	1.9 ± 1.1	2.0 ± 1.1	<0.001
Multivessel PCI	3135 (46.9)	3930 (43.9)	4877 (45.8)	3693 (54.1)	
<b>PCI</b>					
Intravascular ultrasound	1035 (38.6)	1412 (42.5)	1448 (38.7)	662 (38.5)	0.002
Atherectomy					
Laser	15 (0.2)	36 (0.4)	41 (0.4)	34 (0.7)	<0.001
Orbital	0 (0.0)	0 (0.0)	76 (0.7)	144 (3.0)	
Rotational	450 (6.7)	613 (6.8)	914 (8.7)	463 (9.5)	

Thrombectomy					
Aspiration	124 (1.9)	147 (1.6)	174 (1.7)	59 (1.2)	0.054
Mechanical	27 (0.4)	34 (0.4)	36 (0.3)	15 (0.3)	0.822
Cutting or scoring balloon	684 (10.2)	998 (11.1)	1132 (10.8)	442 (9.1)	<0.001
Number of Stents (mean ± SD)	2.3 ± 1.4	2.1 ± 1.3	2.2 ± 1.3	2.2 ± 1.3	<0.001
Bare Metal Stents	1382 (20.7)	1602 (17.9)	1293 (12.1)	554 (8.1)	<0.001
Drug Eluting Stents	5594 (83.7)	7640 (85.3)	9603 (90.1)	6389 (93.6)	<0.001
DES <sup>b</sup> type					
Co Cr EES <sup>c</sup>	3506 (62.7)	3881 (50.8)	3241 (33.7)	1390 (21.8)	<0.001
PI Cr EES <sup>d</sup>	0 (0.0)	1311 (17.2)	3107 (32.4)	1860 (29.1)	
ZES <sup>e</sup>	412 (7.4)	1424 (18.6)	2382 (28.4)	988 (15.5)	
PES <sup>f</sup>	680 (12.2)	464 (6.1)	55 (0.6)	8 (0.1)	
SES <sup>g</sup>	416 (7.4)	11 (0.1)	0 (0.0)	0 (0.0)	
Other DES	6 (0.1)	0 (0.0)	157 (1.6)	1846 (28.9)	
>1 DES type	574 (10.3)	549 (7.2)	661 (6.9)	297 (4.6)	

All values reported as n (%) unless otherwise specified.

a MCS = mechanical circulatory support

b DES = drug eluting stent

c Co Cr EES = cobalt chromium everolimus eluting stent

d PI Cr EES = platinum chromium everolimus eluting stent

e ZES = zotarolimus eluting stent

f PES = paclitaxel eluting stent

g SES = sirolimus eluting stent

**eTable 3.** Clinical outcomes of patients undergoing ULM PCI over time

	<b>2009Q3- 2011Q2</b>	<b>2011Q3- 2013Q2</b>	<b>2013Q3- 2015Q2</b>	<b>2015Q3- 2016Q2</b>	<b>P</b>
	N = 6696	N = 8954	N = 10659	N = 6829	
Death, MI <sup>a</sup> , Stroke or Emergent CABG	620 (9.3)	835 (9.3)	950 (8.9)	543 (8.0)	0.013
Death	295 (4.4)	434 (4.8)	555 (5.2)	359 (5.3)	0.067
MI	303 (4.5)	411 (4.6)	402 (3.8)	169 (2.5)	<0.001
Stroke	35 (0.5)	35 (0.4)	58 (0.5)	48 (0.7)	0.066
Emergent CABG <sup>b</sup>	43 (0.6)	45 (0.5)	46 (0.4)	25 (0.4)	0.102

All values reported as n (%) unless otherwise specified.

a MI = myocardial Infarction

b CABG = coronary artery bypass grafting

**eTable 4.** Clinical outcomes of patients undergoing ULM PCI stratified by tertile of operator and institutional annual PCI volumes and by tertile of institutional use of mechanical circulatory support

	<b>Tertile 1</b>	<b>Tertile 2</b>	<b>Tertile 3</b>	<b>P</b>
<b>Institutional Annual PCI<sup>a</sup> Volume</b>	<b>4 – 162</b>	<b>163-359</b>	<b>&gt;360</b>	
ULM PCI <sup>b</sup> Total per tertile	1236	6379	25513	
Death, MI <sup>c</sup> , Stroke or Emergent CABG <sup>d</sup>	137 (11.1)	623 (9.5)	2188 (8.6)	<0.001
Death	80 (6.5)	397 (6.2)	1166 (4.6)	<0.001
MI	63 (5.1)	230 (3.6)	992 (3.9)	0.045
Stroke	5 (0.4)	32 (0.5)	139 (0.5)	0.752
Emergent CABG	9 (0.7)	39 (0.9)	111 (0.4)	0.083
<b>Operator Annual PCI Volume</b>	<b>4-27</b>	<b>28-64</b>	<b>&gt;65</b>	
ULM PCI Total per tertile	738	6017	26373	
Death, MI, Stroke or Emergent CABG	104 (14.1)	610 (10.1)	2234 (8.5)	<0.001
Death	64 (8.7)	373 (6.2)	1206 (4.6)	<0.001
MI	46 (6.2)	245 (4.1)	994 (3.8)	0.002
Stroke	1 (0.1)	35 (0.6)	140 (0.5)	0.289
Emergent CABG	10 (1.4)	46 (0.8)	103 (0.4)	<0.001
<b>Institutional Use of IABP</b>				
Death, MI <sup>c</sup> , Stroke or Emergent CABG <sup>d</sup>	562 (7.8)	1136 (8.6)	1250 (9.9)	<0.001
Death	333 (4.6)	610 (4.6)	700 (5.5)	0.001
MI	217 (3.0)	517 (3.9)	551 (4.3)	<0.001
Stroke	39 (0.5)	69 (0.5)	68 (0.5)	0.982
Emergent CABG	34 (0.5)	60 (0.5)	65 (0.5)	0.784
<b>Institutional Use of non-IABP Mechanical Circulatory Support</b>				
Death, MI, Stroke or Emergent CABG	277 (10.2)	988 (8.0)	1683 (9.3)	<0.001
Death	157 (5.8)	569 (4.6)	917 (5.1)	0.025

MI	100 (3.7)	405 (3.3)	780 (4.3)	<0.001
Stroke	18 (0.7)	56 (0.5)	102 (0.6)	0.270
Emergent CABG	31 (1.1)	60 (0.5)	68 (0.4)	<0.001

All values reported as n (%) unless otherwise specified.

a PCI = percutaneous coronary intervention

b ULM PCI = unprotected left main percutaneous coronary intervention

c MI = myocardial Infarction

d CABG = coronary artery bypass grafting



**eTable 5.** Baseline characteristics and outcomes in patients who underwent left main PCI in the NCDR, EXCEL trial, and NOBLE trial

	NCDR <sup>a</sup>	EXCEL	NOBLE	p-value
<b>Baseline Demographics</b>				
	n = 33,128	n = 948	n = 592	
Age (mean ± SD)	71.8 ± 12.4	66 ± 9.6	66.2 ± 9.9	<.001
Female gender	13,253 (40.0)	226 (23.8)	116 (19.6)	<.001
White	28,595 (86.3)	844 (91.5)	-	<.001
BMI <sup>b</sup> (kg/m <sup>2</sup> ; mean ± SD)	28.7 ± 8.1	28.6 ± 5	27.9 ± 4.5	0.051
Diabetes Mellitus	13,368 (40.4)	286 (30.2)	86 (14.5)	<.001
Hypertension	28,497 (86.0)	703 (74.5)	386 (65.2)	<.001
Smoking, active	6,447 (19.5)	222 (24.1)	108 (18.2)	<.001
Previous PCI <sup>c</sup>	118,1763 (35.4)	174 (18.4)	116 (29.5)	<.001
Previous CABG <sup>d</sup>	-	0	4 (0.7)	
Congestive Heart Failure	9,176 (27.7)	67 (7.1)		<.001
Indication				
Acute coronary syndrome			106 (17.0)	
STEMI	2,321 (7.0)	13 (1.4)	0 (0.0)	<.001
NSTEMI	8,364 (25.3)	124 (13.2)		<.001
UA <sup>e</sup>	13,881 (41.9)	228 (24.2)		<.001
Stable angina	4,419 (13.3)	500 (53.1)	486 (82.1)	<.001
Silent/unlikely to be ischemic	4,134 (12.4)	73 (7.7)		<.001
<b>Procedure Characteristics</b>				
Contrast volume (mL; mean ± SD)	216.0 ± 114.1	256 ± 127	200 (IQR 150-280)	<.001
Fluoroscopy time (minutes; mean ± SD)	23 ± 16.4	24 ± 16	25 (IQR 11-24)	0.002
Anticoagulation				
Unfractionated heparin	21031 (63.5)	787 (83.0)	411 (72.6)	<.001
Bivalirudin	16048 (48.4)	338 (35.7)	108 (18.9)	<.001
Arterial access site				
Femoral	28,535 (86.2)	744 (72.9)		<.001
Radial	4,323 (13.1)	275 (26.9)		
Brachial	180 (0.5)	2 (0.2)		
Number of lesions treated (mean ± SD)	2.0 ± 1.1	1.0 ± 1.1	2.0 ± 1.5	<.001
Number of stents implanted per patient (mean ± SD)	2.2 ± 1.3	2.4 ± 1.5		<.001
Drug eluting stent used	29,226 (88.2)	2,282 (99.8)		<.001
Lesion involving bifurcation	14,947 (45.1)	763 (80.5)	508 (87.7)	<.001
Two-stent technique (% of bifurcation lesions)	6053 (40.5)		187 (36.8)	<.001
Multivessel PCI	15635 (47.2)		263 (44.4)	0.30

Intravascular ultrasound guidance	4557 (39.8)	722 (77.2)	430 (74.9)	<.001
Mechanical circulatory support	8,169 (24.7)	53 (5.6)		<.001
<b>Outcomes</b>				
Death, myocardial infarction or stroke		137 (15.4)	137 (23.1)	<.001
Death, myocardial infarction or stroke at 30-days or in-hospital	2,993 (9.0)	46 (4.9)		<.001
Death at 30 days or in-hospital	1,643 (5.0)	9 (1.0)	2 (0.0)	<.001
Stroke at 30 days or in-hospital	176 (0.5)	6 (0.6)	0	0.43
Myocardial infarction at 30 days or in-hospital	1,285 (3.9)	37 (3.9)	19 (3.2)	0.73

All values reported as n (%) unless otherwise specified. Proportions listed exclude those with missing data from the denominator. For comparison of mean versus median values, mean was assumed to equal median values, and SD estimated as the IQR divided by 1.35.

a NCDR = National Cardiovascular Data Registry

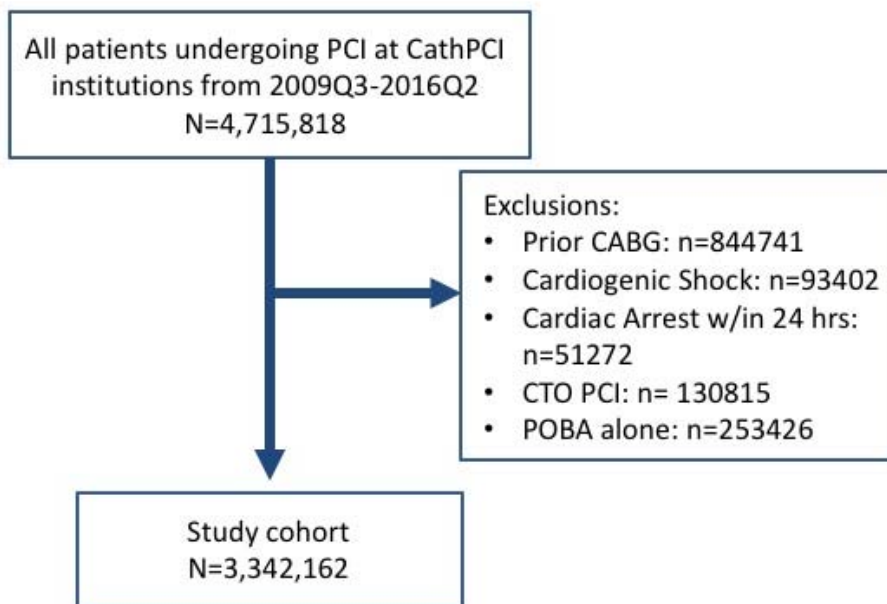
b BMI = body mass index

c PCI = percutaneous coronary intervention

d CABG = coronary artery bypass grafting

e UA = unstable angina

**eFigure 1.** Cohort creation



**eFigure 2.** Factors associated with increased rates of major adverse cardiac events after multivariate adjustment

